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ABSTRACT

Both English language learners (ELLs) and non-ELL students in grades 4 and 8 were tested in mathematics using one of several accommodations during winter 2002. This study compared computer-, customized dictionary-, and extra-time-accommodates test results of ELL and non-ELL students. Test and questionnaire results were examined for 607 students in grade 4 and 542 in grade 8. A reading composite score were used as a covariate, and adjusted scores were obtained. Students' responses to accommodation followup questionnaires and background questionnaires were analyzed. The computer accommodation was the most effective. It provided an alternative test item delivery and an easy-to-access gloss of non-mathematics lexicon. Since non-ELL students who received the same accommodations performed consistently with nonacommodated, non-ELL students, there is evidence that the accommodations do not affect the construct being measured, and thus are valid for assessing the performance of ELL students. As schools increase their technology base, the computer test platform may be the means to provide language accommodation on demand to ELL students and other students not proficient in academic English. One appendix contains details about mathematics test item responses, and the other contains the followup questionnaire results. (Contains 2 figures, 52 tables, and 65 references.) (SLD)

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CSE Technical Report 586

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Project 4.2 Validity of Assessment and Accommodations for English Language Learners
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Executive Summary

With recent legislation calling for equal learning opportunity for all children—including English language learners (ELLs)—the issue of assessment and accommodation for ELLs is gaining more attention. The No Child Left Behind Act of 2001 (2002) asks for fair assessment for all children, including ELL students, and encourages experimentally controlled research to examine issues related to assessment and accommodation for ELL students. Considering the fast-growing nature of the ELL population, this study aims to address several important issues concerning the use of accommodation in NAEP. First, it is important to identify those accommodations that help ELL students perform better by reducing the language barriers in content-area assessments (i.e., accommodations that are effective). A second major task is to make sure that accommodations that are effective in increasing the performance of ELL students do not give them an unfair advantage over non-ELL students not receiving the accommodations (i.e., the accommodations should be valid). We test this by examining whether the accommodations seem to have a positive effect on the performance of non-ELL students. The task of finding effective and valid accommodations is complete with the testing of accommodation feasibility. Therefore, the main objective of this study is to identify accommodations that are effective, valid, and logistically feasible to implement.

Methods

Three main research hypotheses were tested, each related to one of the issues concerning accommodation. They were: (a) effectiveness, (b) validity, and (c) feasibility. A net total of 607 Grade 4 students (279 or 46% ELLs and 328 or 54% non-ELLs) and 542 Grade 8 students (256 or 47% ELLs and 286 or 53% non-ELLs) were tested.[1] The accommodation plan was slightly different for the two grades. Students in Grade 4 were assessed under four different accommodation strategies (computer testing with a pop-up glossary, extra time, a customized dictionary, and small-group testing) and under a standard condition where no accommodation was provided. However, Grade 8 students were tested under two accommodations (computer testing with a pop-up glossary[2] and a customized dictionary) and under the standard condition. The research questions for this study are:

- Which test accommodations are more effective in reducing the gap in performance between ELL and non-ELL students? (effectiveness)

[1] The net total excludes those absent on 1 of the 2 days of testing and those completely non-English-speaking. When accommodated results were compared, the 20 small-group participants were not analyzed.

[2] All mention of computer testing as an accommodation refers to math tests delivered on computers to approximately 8 students. These math tests included a pop-up glossary accommodation, described in the methods section. Most of these students also took the reading proficiency measures on the computer.

- Do the accommodations impact the validity of the assessment (i.e., change the content of the assessment)? (validity)
- Are the accommodations that reduce the performance gap between ELL and non-ELL students (without altering the construct) easily implemented? (feasibility)

Results for Grade 4 Students

The test results of 268 of the 279 Grade 4 ELL students were analyzed. We compared three of the four accommodation conditions to the standard (non-accommodated) condition. Due to school space constraints, too few were tested in the small-group condition to make a comparison. Also, due to the limited number of computers available, a smaller number of students were tested on computer than on paper.

Effectiveness. A comparison between the math scores of ELL students receiving different forms of accommodation with the math scores of ELL students under the standard condition provided evidence of the effectiveness of the accommodations for ELL students. Those accommodations that helped students to perform significantly higher than the standard condition were labeled as effective.

To test for effectiveness, we adjusted for any initial difference in the level of English proficiency by using the reading composite score as a covariate. Adjusted scores were obtained and compared. The adjusted mean score for ELL students under the computer accommodation was 14.922 (SE = .805, n = 35, p = .005); under extra time, the mean was 14.037 (SE = .506, n = 89, p = .012); and under the customized dictionary condition, the mean was 13.372 (SE = .597, n = 64, p = .138), compared to a mean of 12.182 (SE = .533, n = 80) under the standard condition. As these data show, ELL students in Grade 4 performed better under all forms of accommodation that were provided in this study, except the small-group testing.[3] However, the data also suggest that ELL students benefited more from some forms of accommodation than others. For example, ELL students taking the computer test obtained 2.740 score points higher than students under the standard condition. This difference was smaller with other accommodations. The difference in student performance under the extra time condition compared to the standard condition was 1.855. For the customized dictionary accommodation, the difference was 1.190.

The results of planned comparisons suggest that the difference between the performance of ELL students under the computer condition and ELL students under the standard condition was significant at the .005 nominal level, well beyond the .01 nominal level. For extra time, the difference between the accommodated and non-accommodated testing of ELL students was also significant at the .01 nominal level.

[3] Because of the small number of students tested under the small-group accommodation, an adjusted mean is not available.

For the customized dictionary accommodation and small-group testing, the difference between the ELL accommodated and non-accommodated performance was not statistically significant.

Thus, the results of analyses for students in Grade 4 suggest that computer testing and testing with extra time were effective forms of accommodation.

Validity. The test results of 319 of the 328 Grade 4 non-ELL students were analyzed. We compared results from three of the four accommodation conditions with the standard (non-accommodated) condition.[4] For the computer testing, the adjusted mean for non-ELL students was 16.295 (SE = .822, n = 44, p = .262); for extra time, the adjusted mean was 16.55 (SE = .595, n = 84, p = 292); and for the customized dictionary accommodation, the adjusted mean was 17.435 (SE = .565, n = 93, p = .971), compared to an adjusted mean of 17.406 (SE = .550, n = 98) for the standard (non-accommodated) condition.

The results of analyses on adjusted math scores suggest that the differences between the accommodated and non-accommodated assessments for Grade 4 non-ELL students were not statistically significant. That is, non-ELL students performed the same under the accommodated and non-accommodated assessments. These results are encouraging since they suggest that accommodations found to be effective for ELL students in Grade 4 are also valid because they did not affect the construct (math performance).

Feasibility. The project staff and test administrators recorded the feasibility of preparing and administering the accommodations. Each accommodation strategy used in this study had its own logistical pros and cons. Here are a few examples:

- The project staff spent a substantial amount of time developing appropriate glossaries for two of the accommodation conditions in each of the grade levels. This required consultation with content specialists (to make sure content-related terms were not glossed) and students (to make sure that all unfamiliar non-technical terms were glossed).

- The extra time accommodation ran into scheduling difficulties. School administrators and teachers were reluctant to let the testing conflict with the structure of the school-day schedule.

- In administering the computer testing, the main obstacles were access to an Internet connection, adequate computer memory, and current Web browsers. In some schools, there was not a quiet place for students to take tests on computers.

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[4] Again, due to school space constraints, there was not as much computer or small-group testing. In the small-group condition, too few were tested to make a comparison.

- To administer the test in a small-group setting required a separate, quiet testing space that did not exist in most schools.

Results for Grade 8 Students

We analyzed the test results of 256 Grade 8 ELL students assessed under two accommodation conditions: computer testing and customized dictionary accommodations, as well as under the standard condition with no accommodation provided.

Effectiveness. Just as with the Grade 4 results, we adjusted for any initial differences in the level of English proficiency by using the reading composite score as a covariate. The results of the analyses indicate that Grade 8 ELL students performed higher under both accommodations when compared to ELL student performance under the standard condition. For the computer testing, the adjusted mean was 10.656 (SE = .408, n = 84, p = .008); for the customized dictionary, the adjusted mean was 9.838 (SE = .399, n = 86, p = .197); and for the standard condition, the adjusted mean was 9.108 (SE = .401, n = 86).

The results of the analyses using planned comparisons show that increased performance of ELL students under the computer testing was significant beyond the .01 nominal level. However, the increased performance under the customized dictionary condition was not significant for ELL students. These results suggest that computer testing is an effective accommodation for ELL students in Grade 8.

Validity. For the 286 non-ELL students in Grade 8, the adjusted means for the computer testing and for the customized dictionary were slightly higher than the adjusted mean math under the standard condition. For the computer testing, the adjusted mean was 14.674 (SE = .491, n = 68, p = .220); for the customized dictionary, the adjusted mean was 14.205 (SE = .434, n = 87, p = .623); compared to an adjusted mean of 13.930 (SE = .354, n = 131) for students tested under the standard condition.

The results of the analyses for non-ELL students in Grade 8 indicate that none of the comparisons were significant. That is, the two accommodation strategies did not affect the performance of non-ELL students. This suggests that the accommodations used in this study may be implemented without concern for the validity of the accommodated testing.

Discussion

The results of our analyses for Grade 4 revealed that extra time and computer testing were effective forms of accommodations for ELL students. For non-ELL students, the results did not show any significant differences between the accommodated and non-accommodated assessments. Therefore, the two accommodation strategies showed effectiveness, without posing any threat to the validity of the assessment.

The results indicate that only computer testing is an effective accommodation for the Grade 8 ELL students in this study. This accommodation had no impact on the assessment of non-ELL students, suggesting that the computer testing for Grade 8 can be implemented without a validity concern.

This discussion focuses on three major themes, some of which are unique to this study:

1. Computer testing as a form of accommodation for ELL students;
2. Using a composite of multiple measures of students' level of English proficiency; and
3. Accommodation impact on measurement with varying degrees of linguistic complexity.

Computer Testing as a Form of Accommodation for ELL Students

In this study, computer testing was used as an accommodation strategy for elementary and middle school ELL students. The results of analyses indicated that computer testing was the most effective among other accommodation strategies used in this study. The results also indicated that computer testing was a valid accommodation since it did not affect the performance of non-ELL students.

We believe computer testing was effective since it incorporates into the session an interactive set of accommodation features such as presentation of a single item at a time; a pop-up glossary; extra time; and a small and novel setting. An elaboration of these features follows.

The ELL students taking the computer version were presented with a single question at a time on the screen in front of them, rather than 15 test pages, with each page presenting as many as 3 questions. However, test-wise students noticed the disadvantage of not being able to jump ahead to easier (i.e., multiple choice) questions, and then return to the harder ones. A few mouse-savvy students used the right mouse button to go back a page to change an answer.

One of the most important characteristics of the computer testing was the extensive use of its pop-up glossaries by the students. Under the customized English dictionary accommodation, almost no students marked circles to indicate that they had looked up words in the customized dictionary. Students assessed under the computer testing approach, however, used their glossary at a much higher rate than the customized English dictionary group. Delivery of the customized dictionary by computer had some advantages for the students. Instead of searching for an unknown word in an alphabetical glossary, students could use the mouse to point to a word in the test and were presented with a gloss. They were given a brief definition or synonym of that word (or its root) in its present context, rather than being given all the possible definition entries. (No math terms were glossed.)

Whether it was the novelty of taking a test on a computer—usually in a separate room—being presented one item at a time, and/or having words glossed by sliding the mouse—ELL students seemed to enjoy the computer testing strategy. We were expecting that the randomly selected non-ELL students would perform significantly better on the computers than their "paper-test" peers because of the novel test delivery in a familiar medium. (Many more of the non-ELL students have computers at home than the ELL students—66% non-ELLs compared to 49% ELLs—and a surprising number of non-ELLs were touch typists.) However, Grade 8 non-ELLs performed only slightly better on the computer math test than their peers did on the paper test. This difference did not reach a significant level ($p > .05$).

Students expressed enjoyment of the computer delivery of the test, despite the predominance of "hunt and peck" typing. All students indicated in their background questionnaires that they had more fun with computer testing than with any other accommodation used in this study.

However, there are some logistical concerns with the computer accommodation. Because Internet access was required for administering the computer version of the math and reading tests, testing was limited to certain schools, certain rooms and computers of a certain size. Difficulties beyond the scope of the students or "delivery" computers interrupted testing: a power outage, the UCLA host server being rebooted during a test, and the data server crashing. Because of technical difficulties, some students took the math test on computer, but took the reading test on paper.

Using a Composite of English Proficiency Measures

Due to the importance of English proficiency measures in the instruction, assessment, and classification of ELL students, we tried to establish a more reliable and valid measure of students' level of English proficiency by compiling a battery of existing measures that are shown to have good measurement properties. We used three measures in this battery: (a) a subscale of the LAS (reading fluency) which has higher discrimination power than other LAS subscales, (b) a 25-minute NAEP reading comprehension block, and (c) a word recognition test. We created a simple composite and a latent composite of these components and used these composites as covariates to adjust for any possible initial differences of students' level of English proficiency.

An English word recognition measure was used on an experimental basis as one of the components of the English language proficiency battery. The results of this study show that this word recognition measure had a significantly high correlation with other reading measures, (so it has some value as an efficient form of reading measurement) but was very likely more difficult to take on a computer than on paper, as the results were so much lower. For this reason, it was not used as a covariate in the primary analysis.

Impact of Accommodations According to Linguistic Complexity of Test Items

We categorized math test items based on the level of their linguistic complexity and examined the effectiveness and validity of accommodations on the linguistically more complex and less complex items. For the more linguistically complex items, all the accommodations, compared to the standard administration, made a significant difference in the performance of Grade 4 ELL students. For Grade 8 ELL students, we found that the computer accommodation made a significant difference for the more linguistically complex items ($p = .001$), but it was not significant for the items that were less linguistically complex. For the less complex Grade 4 math items, the computer and extra time accommodations were still significant. For non-ELL students in Grades 4 and 8, there was no significant accommodation effect; therefore, validity was not a concern for any of the items in either grade.

Recommendations

No test accommodation results can be considered completely conclusive without consideration of what students have had the opportunity to learn. For example, if an ELL student has not been taught ratios in a "sheltered" math class, a language accommodation will be of little help on a ratio problem.

In this study, we find that the effective accommodation is a valid one. That is, it can be used on both ELL and non-ELL students without the concern of changing the construct under measurement. Grade 8 students, for whom the effectiveness of the computer accommodation was greatest, often used the glossary. Thus, we recommend this accommodation when large numbers of ELL students are included in the assessment. This use, of course, is dependent on the growing feasibility of assembling particular computer tests and administering them at school sites.

RESEARCH-SUPPORTED ACCOMMODATION FOR ENGLISH LANGUAGE LEARNERS IN NAEP

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Abstract

Both English language learners (ELLs) and non-ELL students in Grades 4 and 8 were tested in math using one of several accommodations during the winter of 2002. The results in this report compare computer-, customized dictionary-, and extra-time-accommodated test results of both ELL students and non-ELL students. A reading composite score was used as a covariate, and adjusted scores were obtained. Students' responses to accommodation follow-up questionnaires and background questionnaires were analyzed. The computer accommodation was the most effective. It provided an alternative test item delivery and an easy-to-access gloss of non-math lexicon. Since non-ELL students who received the same accommodations performed consistently with non-accommodated, non-ELL students, there is evidence that the accommodations do not affect the construct being measured and, thus, are valid for assessing the performance of ELL students. As schools increase their technology base, the computer test platform may be the means to provide language accommodation on demand to ELL students and other students not proficient in academic English.

For non-native English speakers and for speakers of English dialects, every test given in English becomes, in part, a language or literacy test. Therefore, there are challenges in testing individuals who have not had substantial exposure to the English used in tests. Test results may not reflect accurately the abilities and competencies being measured if test performance depends on these test takers' knowledge of English. Thus special attention may be needed in many aspects of test development, administration, interpretation, and decision-making.

Standardized testing is being used to make a variety of important decisions. The diligence of schools and teachers is assessed via tests. Students are promoted to the next grade or held back, depending on their state exams. Students who speak a non-English language at home are often designated "limited" or "fluent" in their English proficiency based on the results of a standardized test. Later, other tests are used to decide if English language learners (ELL) are ready to move from sheltered content instruction. The reliability and validity of ELL student test scores is an issue of great interest to schools, teachers, parents and students. As it concerns the rights to equal access to education—and everyone's tax dollars—the issue of English Language Learners is

discussed in public circles of debate, such as legislative houses, the media, and the courts.

By school year 2005-2006, the three state assessments given in Grades 3-12 will be increased to annual assessments in Grades 3-8 plus a high school assessment, as mandated by the No Child Left Behind Act of 2001 (2002) (See Title 1, Part A, Section 1111 [B] [2]). Limited English proficient students "must be provided reasonable accommodations, including 'to the extent practicable,' in the language and form most likely to yield accurate and reliable information on what they know and can do in content areas" (See Section 1111 (4) (a)). Another provision of the act includes annual English language proficiency testing of all limited-English-proficient students beginning in the 2002-2003 school year [See Section 1111 (B) (3) (a)].

In taking math, science, and other content assessments, some English language learners may have the content knowledge and/or the cognitive ability needed to perform successfully on assessment tasks, but are not yet able to demonstrate in English what they know. Therefore, assessment procedures may not be equitable and may not yield valid results for ELL students (Gandara & Merino, 1993; LaCelle-Peterson & Rivera, 1994). The Standards for Educational and Psychological Testing (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 1999) point out that whenever students are tested in English, regardless of the content or intent of the test, their proficiency in English will also be tested. This is especially relevant for students tested in English who are still in the process of learning English.

NAEP and Accommodation

The 1996 National Assessment of Educational Progress (NAEP) main assessment in math is a milestone in the assessment of limited-English-proficient (LEP) students by introducing the concept of multiple samples (S1, S2, S3) and by including the bilingual math booklet and other forms of accommodation in the assessment.

Since then, NAEP continues to use accommodation in assessing LEP students. However, the number of accommodated students remains very small compared to the number of LEP students included in the assessment. For example, in the 1998 national reading assessment, 896 LEP students were included in the Grade 8 sample (about 7% of the total Grade 8 sample) but only 31 of those (about 3% of the included LEP students) were accommodated. Similarly, in 1998 Grade 4 reading, 975 LEP students (11.5% of the total Grade 4 sample) were included, but only 41 of them (4%) were

accommodated. There may be several reasons for not providing accommodations for all or the majority of LEP students. Issues concerning feasibility and validity of accommodations may be among the strongest. Carefully designed systematic studies are needed to address the validity and feasibility issues.

In the pilot study (*The Effects of Accommodations on the Assessment of LEP Students in NAEP*, Abedi, Lord, Kim, & Miyoshi, 2000) conducted during the 1999-2000 school year, we began an examination of the effectiveness of accommodations by addressing the difficulty of English vocabulary within test items in a NAEP science assessment. We compared ELL and non-ELL students' scores on 20 items and found that ELL students did particularly well using a customized dictionary, whereas the non-ELL students' scores did not seem significantly affected by the same condition. The pilot study contributed to the design of this main study that examines two delivery systems for the customized dictionary accommodation and compares them with three other accommodation conditions.

Testing Accommodation Itself

The impact of various accommodation strategies on NAEP outcomes (the validity issue) must be assessed to see if it closes or reduces the gap between ELL and non-ELL students without altering the construct under measurement. As for feasibility, those accommodation strategies that are more easily implemented in large-scale assessment are the most useful, whereas strategies that are expensive, impractical, or logistically complicated are unlikely to be widely accepted. Thus, for an accommodation strategy to be considered by NAEP, it must be effective, valid, and relevant to students' background characteristics. It must also be feasible, since in large-scale assessments, feasibility is of paramount concern.

Effectiveness. An ELL accommodation strategy is effective if it significantly increases the performance of ELL students. That is, ELL students under an effective accommodation perform significantly better than ELL students with no accommodation. ELL accommodations typically attempt to reduce the non-content language load of the test items by rewriting the item, glossing the non-content words and/or allowing extra time for deciphering the test item language.

Validity. The main concern in using any form of accommodation for ELL students is the validity of accommodated assessment. Researchers argue that some forms of accommodation may alter the construct under measurement and thereby may provide unfair advantage to the recipients. To examine the impact of accommodations on the

construct, both ELL and non-ELL students must be assessed under the accommodated condition. If the accommodated, non-ELL students perform significantly better than their non-accommodated, non-ELL peers, the validity of the accommodation becomes suspect. A validity-suspect language accommodation might be the provision of a full English dictionary containing definitions for terms being tested. With access to definitions of science or math terms, for example, accommodated students would have an unfair advantage over non-accommodated students.

While there are many school districts nationwide that are providing or allowing accommodations for ELL students (such as extra time and prescribed bilingual glossaries), these accommodations are not being provided for non-ELL students; consequently, there is no way to check the validity of the accommodation. Testing accommodation on non-ELL students is something that has not been practical in NAEP testing either. Furthermore, the accommodation impact must be assessed under an experimentally controlled condition. Our study provides ELL and non-ELL students the same form of accommodation in order to determine the impact of the accommodation on the construct under measurement.

Feasibility. An important criterion for any accommodation strategy is feasibility of administration, especially in large-scale assessments. Some forms of accommodation may prove to be effective but may not be feasible. We propose to test highly feasible accommodations. Our goal is to identify accommodation strategies that are not only effective but are also practical to administer. Feasibility and ease of use would encourage the use of accommodations, thereby helping to increase the level of inclusion of ELL students in the NAEP assessments.

Research Questions

In this study, we focused on three major concerns in test accommodation for students with limited English proficiency: (a) effectiveness; (b) validity; and (c) feasibility. Several research questions are addressed by this accommodation study.

- Which test accommodations are more effective in reducing the gap in performance between ELL and non-ELL students? (effectiveness)
- Do the accommodations impact the validity of the assessment (i.e., change the content of the assessment)? (validity)
- Are the accommodations that reduce the performance gap between ELL and non-ELL students (without altering the construct) easily implemented? (feasibility)

Accommodations Selected for This Study: Type and Rationale

The several types of accommodations used in this study were: a computerized administration of each math test, which included a pop-up glossary, a customized English dictionary, an extension of testing time, and small-group testing. There was a slight difference in the plan of accommodations for Grades 4 and 8, in that extended time and small-group testing were included only for Grade 4 students, as middle schools have even more space and time constraints than elementary schools.

The pilot phase of this study suggested that a customized English dictionary was effective in reducing the performance gap between ELL and non-ELL students and at the same time did not affect the construct; therefore, providing this accommodation to ELL students did not compromise the validity of assessment. At the same time, the customized dictionary was easy to administer in large-scale assessments; therefore, feasibility did not inhibit using this form of accommodation. The customized English dictionary was a glossary of non-content words in the math test. It was composed of exact excerpts from an ELL dictionary. In a new type of glossary, brief pop-up glosses of the same words were incorporated into each of the two computer-based math tests we used.

We also included two strategies used in NAEP assessments. In this study, small-group testing (as a feasible replacement for one-on-one testing) and extension of testing time were used with some Grade 4 students.

Instrumentation

Several different instruments were used in this study. Some of these instruments were developed and tested in prior CRESST studies and refined for this study. They include math tests for Grades 4 and 8, reading proficiency tests for each grade, accommodation follow-up questionnaires, student background questionnaires, a teacher questionnaire, and a school questionnaire. All the instruments were field tested.

Design

The main accommodations study was conducted at two grade levels (Grades 4 and 8) in a single urban public school district in southern California, with nearly half of the participants classified as limited English proficient.

The design of this study was a quasi-experimental design. Students within intact classrooms initially were randomly assigned one of several accommodation conditions or to a control group where no accommodation was offered. However, because of

limited space and equipment, a smaller number of students were assigned to the computer and small-group testing accommodations. For the computer testing, over half of the students who initially would have been assigned to the computer condition were randomly distributed to other conditions. For the small-group testing, the number of students reassigned to other conditions was even larger. For the testing of Grade 4 students with the extra time accommodation, entire classes were chosen.

After excluding a small number of participants from the study because they were completely non-English-speaking or were absent on one of the two days of testing, we examined the test and questionnaire results from a net total of 607 students in Grade 4 and 542 students in Grade 8. (See Appendix A, Tables A1 and A2, for gross totals.) Also, as there were too few Grade 4 students in the small-group accommodation condition with which to make accommodation comparisons, slightly fewer test results were analyzed.

To evaluate the impact of accommodation on student performance, both ELL and non-ELL students took the assessment with no accommodation. These two groups served as comparison groups. Most of the ELL students spoke Spanish as a home language. The non-ELL students were a mixture of students designated as "English-only," (EO) and as "re-designated" (RFEP) students and "fluent" (FEP) students from a variety of language backgrounds. Many spoke Spanish as a home language.

The minimum number of subjects per cell was calculated through a power analysis (see Kirk, 1995, pp. 60-64) using the variance that was obtained in an earlier, similar CRESST accommodations study (Abedi, Lord, & Hofstetter, 1998). This number of subjects has proven to be sufficient for the analytic work needed for research and policy purposes. We analyzed the results of 1,149 participants in this study.

ELL designation was used as the main independent variable; however, student background variables (including language background variables) served as additional independent variables. The impact of those variables on student-accommodated performance was examined. This design, with 50 to 150 students per cell, has built-in safeguards for testing differences between ELL students by their background variables.

The results of these analyses help in understanding any differential impact of accommodation on students' performance.

Literature Review

Uses of Standardized Tests

Both federal and state legislation now require inclusion of all students in large-scale assessments in an effort to provide fair assessment and uphold instruction standards for every child in this country—including the English language learners (ELLs[5]) previously exempted from testing (see the Individuals with Disabilities Education Act Amendments of 1997 and the Improving America's Schools Act of 1994). The reauthorization of Title I of the Elementary and Secondary Education Act of 1965, known as the No Child Left Behind Act of 2001 (2002) calls for stronger accountability and mandates inclusion of limited English proficient students and the provision of reasonable accommodations. Accommodations can include "to the extent practicable, assessments in the language and form most likely to yield accurate data on what [ELL] students know and can do in content areas" [See Title I, Part A, Sec. 1111 (3)(C)(ix)(II)]. While raising expectations for ELL students and improving their level of assessment participation, this latest legislation adds a call to improve the validity and equitability of the inferences drawn from standardized assessments. This subsequently affects their design, delivery, interpretation, and use.

The challenge of serving and assessing those ELL students considered limited English proficient (LEP) continues to grow. According to the Summary Report of the Survey of the States' Limited English Proficient Students and Available Educational Programs and Services, 1999-2000, more than 4.4 million LEP students were enrolled in public schools, representing almost 10% of the total public school enrollment of students in pre-kindergarten through Grade 12 (Kindler, 2002). California enrolled the largest number of public school LEP students (1,480,527), which is one third of the total national LEP enrollment. The state with the second highest number of LEP students was Puerto Rico (613,019), followed by Texas (554,949), Florida (235,181), and New York (228,730). Since the 1997-'98 school year, there has been a 27.3% increase in LEP enrollments, the greatest in South Carolina, (82% increase) and Minnesota (67% increase) (see Kindler). With this evolution in school demographics, and with continued calls for accountability, student assessment fairness and validity remain crucial issues

[5] In this report, the descriptor *English language learner* or *ELL* signifies a student whose English proficiency is considered "limited." The designation *limited English proficient* or *LEP* is also used—without any disrespect—to describe the target students in this study or in studies mentioned in the research literature.

on national, state, and school district agendas, as well as in the courts and the popular media.

Besides the use of standardized achievement tests for accountability and/or grade promotion, they are frequently used for assessment and classification of ELL students. These tests are used by approximately 52% of school districts and schools to help identify ELL students, assign them to school services, and reclassify them from ELL status. About 40% of districts and schools use achievement tests for assigning ELL students to specific instructional services within a school, and over 70% of districts and schools use achievement tests to reclassify students from ELL status (Zehler, Hopstock, Fleischman, & Greniuk, 1994).

More and more states implement high-stakes assessments that include ELL students, and a significant number of ELL students are having difficulty passing such tests (Liu & Thurlow, 1999; Liu, Thurlow, Thompson, & Albus, 1999).

Even when standardized, content-based tests (such as science and math tests) are used as achievement tests, they are conducted in English and are normed on native English speaking test populations. Therefore, for ELL students, standardized tests become as much a test of English language skills as a test of academic content skills (Liu, Anderson, Swierzbin, & Thurlow, 1999). Abedi, Lord, and Plummer (1997) found that students' language proficiency could adversely affect their performance on standardized tests administered in English. Using standardized tests normed only for a monolingual English population casts doubts on the validity of these tests for ELL students (LaCelle-Peterson & Rivera, 1994).

Performance Differences Between ELL and Non-ELL Students

English language learners may be unfamiliar with the linguistically complex structure of questions, may not recognize vocabulary terms, or may mistakenly interpret an item literally (Duran, 1989; Garcia, 1991). Additionally, they may perform less well on tests because they read more slowly (Mestre, 1988). Thus, language background factors are likely to confound ELL students' ability to show what they know and thus reduce the validity and reliability of inferences drawn about their content-based knowledge. The Standards for Educational and Psychological Testing (AERA, APA, & NCME, 1999) reminds us that test results may not measure what is intended with "individuals who have not sufficiently acquired the language of the test." Even native speakers of some dialects of English may not be measured accurately if the English used on a test is too complex or unfamiliar (p. 91).

Findings of a series of studies conducted by the National Center for Research on Education, Standards and Student Testing (CRESST) on the impact of students' language backgrounds on their performance indicated that:

- students' language backgrounds affect their performance in content-based areas such as math and science;
- the linguistic complexity of test items may threaten the validity and reliability of achievement tests, particularly for ELL students; and
- as the level of language demand decreases, so does the performance gap between ELL and non-ELL students.

(See Abedi, Courtney, & Leon, 2001; Abedi & Lord, 2001; Abedi, Lord, Hofstetter, & Baker, 2000; Abedi & Leon, 1999; Abedi, Leon, & Mirocha, 2001).

In addition to language difficulties, there are several cultural variables—such as student disinclination to ask questions during testing—that may influence test results for those who are not completely acculturated to the United States. Other cultural variables include attitudes toward competition, attitudes toward the importance of the individual versus the importance of the group or family, a belief in fate versus belief in individual responsibility, gender roles, attitudes toward the use of time, attitudes toward the demonstration of knowledge, use of body movements and gestures, proximity, and use of eye contact (Liu, Thurlow, Erickson, Spicuzza, & Heinze, 1997). Analyses from students' background questions and math and reading scores (Abedi et al., 1998) indicated that language-related background variables, the length of time of stay in the United States, overall Grades, and the number of school changes, were valuable predictors of ELL students' performance in math and reading.

Exemption From Exams

Because of the many issues raised by testing ELL students with exams in English, many ELL students have traditionally been exempted from large-scale assessments.

According to Cummins (1980), most ELL students take between 1 and 3 years to develop the basic interpersonal communication skills that allow them to communicate in English at a very superficial level with peers and teachers. The time it takes ELL students to acquire the cognitive academic language proficiency that is necessary for them to actively participate in their classroom learning, however, is between 5 and 7 years (Collier, 1987; Cummins, 1981). Understandably, many students have traditionally been exempted from exams. Most local and state assessments still allow for

the exemption of some ELL students, but they also administer various test accommodations, based on cost considerations, political expediency, or feasibility of administration (Kopriva, 2000).

According to the Summary Report of the 1999–2000 State Student Assessment Programs annual survey (Council of Chief State School Officers [CCSSO], 2001), official criteria for exemption are often based on one or more of the following:

- time living in the United States
- time in an English as a Second Language (ESL) program
- formal assessments of English
- informal assessments of English

Local communities, schools/districts, parents, or a combination of these decide assessment exemptions (for practices in specific states, see Rivera, Stansfield, Scialdone, & Sharkey, 2000; Roeber, Bond, & Connealy, 1998). NCLB, however, requires the assessment of all children, including ELLs. The legislation recognizes that exempting students from assessments does not provide a measurement for progress and may not allow students any opportunities, such as additional instruction, that could be offered based on the assessments. Furthermore, in order for system accountability to work, it must include all students. Not including ELL students in statewide accountability systems can have a negative impact on the students' learning by lowering the expectations for these students and leaving the school programs for these students unaccountable for their progress (LaCelle-Peterson & Rivera, 1994; Rivera & Stansfield, 1998; Saville-Troike, 1991; Zlatos, 1994). Instead, there must be more appropriate instruments to monitor and report the progress of ELL students across districts, states, and the nation.

Echoing these concerns, a symposium addressing high-stakes assessment (National Clearinghouse for Bilingual Education [NCBE], 1997) made several recommendations about appropriate accommodations for ELL students. A panel at the symposium recommended that assessments mainly be used to help educators improve instruction. The panel added that, in addition to providing accommodation in the administration of assessments, scoring rubrics for open-ended items must be sensitive to the language and cultural characteristics of ELL students. Another panel at the symposium recommended that researchers attempt to determine when ELL students are prepared to take specific tests (see NCBE).

Accommodation Defined

In an earlier incarnation of the No Child Left Behind Act—The Improving America's Schools Act of 1994—we find the mandate: "Limited-English-proficient students . . . shall be assessed to the extent practical in the language and form most likely to yield accurate and reliable information on what students know and can do to determine such students' mastery of skills and subjects other than English." The debate on what form such assessments should take continues. Accommodations, sometimes referred to as *modifications* or *adaptations,* are intended to "level the playing field," so that students may provide a clearer picture of what they know and can do, especially with regard to content-based assessments (e.g., mathematics and science), where performance may be confounded with their English or home language proficiency or other background variables. Accommodations are not intended to give ELL students an unfair advantage over students not receiving an accommodated assessment.

The umbrella term "accommodation" includes two types of changes: modifications of the test itself and modifications of the test procedure. The first type, changes in the test format, includes translated or adapted tests, for example.:

- a translation of the assessment into the student's home language;
- a bilingual version of the test (items in English and in home language);
- modification of linguistic complexity in the test; or
- incorporation of home language and/or English glossaries into the test.

These accommodations may directly address the linguistic needs of the student, but they must be chosen with knowledge of the students' literacy level in the home language, and the students' exposure to glossary use. Modified tests must be designed with care to ensure that the accommodated format does not change the construct being measured. For this reason, schools have more often employed accommodations of the second type: changes in the test procedure. Examples (from Rivera et al., 2000) include:

- allowing English language learners to have extended time to take the test on the same day;
- multiple testing sessions, small group or separate room administration, or individual administration;
- administration by a familiar test administrator;
- availability of published dictionaries or bilingual glossaries;

- simplified directions;
- repeated instructions;
- translating the directions; or
- reading the directions or questions aloud.

Validity Questions

When testing academic achievement in content areas, assessments must provide valid information about student ability in specific content areas, such as math or science. Ideally, instruments will yield beneficial and accurate information about student learning. In order to provide the most meaningful achievement data, several questions are addressed when evaluating assessments (LaCelle-Peterson & Rivera, 1994). The first set of questions concern test validity.

> Is the test valid for the school populations being assessed—including ELL students?
>
> Have available translations been validated and normed?
>
> Has the role of language been taken into account in the scoring criteria?
>
> Do the scoring criteria for content area assessments focus on the knowledge, skills, and abilities being tested, and not on the quality of the language in which the response is expressed? Are ELL students inappropriately being penalized for lacking English language skills?
>
> Are raters who score students' work trained to recognize and score ELL responses?

And to examine assessment equity, the following are asked.

> Are ELL students adequately prepared and instructed to demonstrate knowledge of the content being assessed?
>
> Have ELL students been given adequate preparation to respond to the items or tasks of the assessment?
>
> Has the content of the test been examined for evidence of cultural, gender or other biases?
>
> Is the assessment appropriate for the purpose(s) intended?
>
> Has appropriate accommodation been provided that would give ELL students the same opportunity available to monolingual students?

Appropriate test accommodation helps "level the playing field" by ensuring the validity of the test for all students. To do this, it is important for accommodation not to give an advantage to students who receive them over students who do not (Rivera & Stansfield, 1998). For example, students who have access to standard published dictionaries during an assessment may be able to correctly respond to certain items only because the answer to the item is contained within a dictionary definition (see Abedi, et al., 1998; Abedi, Lord, Hofstetter et al., 2000). Another example of an unfair advantage is providing extra time to ELL students in a "speed test." This validity problem was verified when non-ELL students with extra time scored higher than other, comparable non-ELLs without extra time who were not able to complete the test items (Hafner, 2001). An extra time accommodation may be valid when speed is not being tested and the language of the test items merits extra time for "decoding" or using a glossary accommodation.

Accommodation may improve the accuracy of test scores by eliminating irrelevant obstacles for ELL students (Rivera & Stansfield, 1998). Therefore, scores earned on tests with appropriate accommodation are more likely to maintain the validity of the test and minimize error in the measurement of the student's abilities. These tests will be more of a measure of the individual's true ability in the subject being assessed than scores earned on tests without appropriate accommodation. The accommodation may also increase the comparability of scores (Rivera & Stansfield).

Linguistic Complexity of Test Items

Standardized achievement tests attempt to measure students' knowleuge of specific content areas. However, analyses of mathematics and science subsections of 3rd- and 11th-grade standardized content assessments by Imbens-Bailey and Castellon-Wellington (1999) pointed out that two thirds of the items include non-content vocabulary considered uncommon or used in an atypical manner. One third of the items included complex or unusually constructed syntactic structures. To accurately assess knowledge within content areas, students must comprehend what the items are asking and understand the response choices.

Analyses based on the linguistic complexity of items (Abedi et al., 1997) revealed significant differences with respect to language background between student scores on complex items and less complex items. Research clearly shows the impact of students' language background on their performance on math word problems (see, for example,

Abedi & Lord, 2001). Language backgrounds may also impact scores on science tests if language comprehension, rather than content knowledge, is reflected in scores.

Linguistic Modification of Test Items

In studies examining the language of math problems, making minor changes in the wording of a problem affected student performance (Cummins, Kintsch, Reusser, & Weimer, 1988; De Corte, Verschaffel, & DeWin, 1985; Hudson, 1983; Riley, Greeno, & Heller, 1983, for example). Larsen, Parker, and Trenholme (1978) compared student performance on math problems that differed in sentence complexity and level of familiarity of the non-math vocabulary. Low-achieving Grade 8 students scored significantly lower on the items with more complex language. Recent studies using items from the NAEP assessments compared student scores on actual NAEP items with parallel, modified items in which the math task and math terminology were retained but the language was simplified. In studies that have found significant improvements in the scores of students answering linguistically simpler versions of test items, the linguistic features that appeared to contribute to the item difficulty were low-frequency vocabulary and passive voice verb constructions, and longer problem statements (Abedi et al., 1997; Abedi et al., 1998; Abedi & Lord, 2001). In a study testing 946 Grade 8 students in math with different accommodations including modified linguistic structures, provision of extra time, and provision of a glossary, only the modified-language accommodation narrowed the score gap between English language learners and students proficient in English (Abedi, Courtney, & Leon, 2001). Rivera and Stansfield (2001) compared student performance on regular and simplified science items in Grades 4 and 6. Although the small sample size did not show significant differences in scores for English language learners, the study did demonstrate that linguistic simplification did not affect the scores of the English-proficient students, indicating that linguistic simplification is not a threat to score comparability.

It is interesting that students have indicated preferences for items that were simpler linguistically in interviews and scored higher, on average, on linguistically modified items. The linguistic modification had an especially significant impact for low-performing students. ELL students performed better on linguistically modified test items than did proficient speakers of English. (Abedi, Courtney, & Leon, 2001; Abedi & Lord, 2001).

Effects of Other Language Accommodation

This study focuses on accommodations that directly address the students' anticipated difficulty with the language of the text. This section summarizes several findings pertinent to the effectiveness, validity, and feasibility of the approaches used in this study. We discuss assessments that provide a glossary and the provision of extra time.

Customized English dictionary use. In order to overcome the main disadvantages of commercial dictionary use as an accommodation (such as accidental provision of test content material, difficult format and language, the difficulty of providing dictionaries, and disuse), this study created customized glossaries and dictionaries that are defined and discussed here.

A study of 422 students in Grade 8 science classes (Abedi, Lord, Kim et al., 2000) compared performance on NAEP science items in three test formats: one booklet in original format (no accommodation); one booklet with English glosses and Spanish translations in the margins; and one booklet with a customized English dictionary at the end of the test booklet. The customized dictionary included only words that appeared in the test items. English learners scored highest on the customized dictionary accommodation. Interestingly, although the accommodations helped the English learners score higher, for the English-proficient students there was no significant difference between their scores in the three test formats. This suggests that these accommodation strategies did not affect the construct.

Abedi, Courtney, & Leon (2001) found that linguistically modified testing, extra time, and glossary plus extra time helped ELL students. The results also suggest that the effectiveness of accommodation strategies, to some extent, may depend on the students' background variables, particularly their language background variables.

Extra time. Allowing more time to complete test sections than is normally allotted is a common accommodation strategy that does not require changes to the test itself. It is considered a language accommodation because it may facilitate the decoding of test language, with or without a glossary or dictionary. This accommodation may lead to higher scores for English learners (Hafner, 2001; Kopriva, 2000).

There is no conclusive research to date on the validity of extra time as an accommodation strategy for ELL students. In a study allowing extra time to samples of both LEP and non-LEP students, the students with the extra time condition showed the highest scores (Hafner, 2001). While extra time helped Grade 8 English learners on

NAEP math tests, it also aided students already proficient in English, creating doubts of its validity as an assessment accommodation for ELL students (Abedi et al., 1998; Abedi, Courtney, & Leon, 2001). It seems that if extra time is allotted, it should be given to all students.

Despite the validity problems, extra time is considered a necessary addition when time-consuming accommodations are provided. A study providing glossaries with extra time (Abedi, Lord, Kim, et al., 2000) on Grade 8 math tests for 946 Southern California students found that both English language learners and English-proficient students performed significantly higher when extra time was provided along with the glossary.

Effects of Setting Accommodation

As mentioned above, the NAEP 1996 tests permitted one-on-one testing and small-group testing of ELL students in the third sample of schools (Olson & Goldstein, 1997). Except for the use of small-group testing for students with disabilities, there is a dearth of research on its use in assessing ELL students.

Reading Assessment of Proficient and Non-proficient Readers

This study used a reading assessment for each grade that consisted of three types of measures: a word recognition test, a multiple-choice fluency section of the Language Assessment Scales (LAS), and a NAEP reading block. Reading proficiency assessments are normed for either non-ELL students (such as NAEP's reading comprehension blocks) or for ELL students (such as the LAS test battery). There seems to be no single written assessment suitable for both types of readers. Since this study used a combination of measures for both ELL and non-ELL students, here is a discussion of findings on the types of measures in our reading battery.

LAS fluency section & NAEP reading block. The Fluency section of the Language Assessment Scales showed a higher level of discrimination power in assessing reading ability among limited-English-proficient students in a previous CRESST study (Butler & Castellon-Wellington, 2000), whereas intact blocks of NAEP reading items provided a good distribution among English-proficient students in the pilot portion of an earlier study (Abedi, Courtney, Mirocha, Leon, & Goldberg, 2001).

Word recognition. In one second or less, a sight word is recognized without pausing to break it into parts (phonemic decoding). Once students have a large vocabulary of sight words, they are free to concentrate on constructing the meaning of

text (Gough, 1996). Since word recognition is central to the reading process (Chard, Simmons, & Kameenui, 1998), word recognition tests may help to determine reading levels.

The Eurocentres Vocabulary Size Test (EVST) (Meara & Buxton, 1987; Meara & Jones, 1988) has been used to estimate the vocabulary size of ELL students in language schools. The EVST estimates a student's vocabulary size by using a graded sample of words covering numerous frequency levels. This test also uses non-words to provide a basis for adjusting the test-takers' scores if they appear to be overstating their vocabulary knowledge. A distinctive feature of the EVST is that a computer administers it. Some schools have viewed the EVST as an efficient and accurate placement procedure, able to assign students to classes with minimum administrative effort (Read, 2000).

The great attraction of EVST's checklist style test format in the estimation of vocabulary size is how simple it is to construct, administer, and take. The simplicity of the task means that a large number of words can be covered within the testing time available, which is important for achieving the sample size necessary for making a reliable estimate (Read, 2000).

State Policies on Accommodation

States vary on policies regarding the identification of ELL students and the role of accommodation on assessments for ELL students. During the 1998-1999 school year, 40 states had accommodation policies and 37 of the 40 allowed accommodations (Rivera et al., 2000), bringing accommodation use to 74% nationwide.

California and Texas are the two states with the largest populations of Spanish-speaking ELL students. Following is a summary of their state policies on accommodation. (For a more detailed look or for information on other states, see Rivera et al., 2000.)

In California, students are classified as ELL students based on home language surveys, English oral/aural proficiency tests, and grade-appropriate literacy tests. Test exemptions are not allowed in California. There is not a specific California State policy regarding accommodation on assessments for ELL students (California Department of Education, 2000; Rivera et al., 2000).

In Texas, ELL students are identified based on home language surveys, oral language proficiency tests, informal assessments through teacher/parent interviews,

student interview or teacher surveys, standardized achievement test scores, and classroom Grades. Since the 2000-'01 school year, all Texas ELL students take the Texas Assessment of Academic Skills (TAAS) in English or Spanish unless the student is a recent unschooled immigrant enrolled in U.S. schools for 12 months or less. Testing accommodations are permitted, except those that make a particular test invalid as a measure for school accountability. The permissible accommodations include translation of directions on all components in a student's home language and translation of some components of the test in a student's home language. School district officials are the decision-makers of ELL accommodation.

In general, state policies on the process of identifying ELL students contain some similarities, including collecting information from assessments and home language. Not all states have specific accommodation policies, although all states seem to be addressing the issues of including all students in large-scale assessments. However, more research is needed to determine the best means of accommodating ELL students.

Participation With Accommodation

Evidence indicates that the provision of accommodation results in higher rates of participation for ELL students (Mazzeo, Carlson, Voelkl, & Lutkus, 2000; O'Sullivan, Reese, & Mazzeo, 1997).

The Summary Report of the 1999–2000 State Student Assessment Programs (CCSSO, 2001) annual survey examined participation in state assessments by ELL students and found that 29 states allowed accommodations for ELL students in all assessments, 18 allowed them with some assessments, and four did not permit any accommodations for ELL students. An alternate assessment, often used for the least English proficient who would have been excluded before, was possible for ELL students in 16 states. A variety of accommodations were allowed that year: ELL students were assessed in a modified setting (44 states); with a modified format of presenting the assessment (43 states), such as directions read aloud, interpreted, repeated, etc.; with a change of timing or scheduling (41 states); and/or with a modified method of responding to the questions, such as marking responses in the booklet, using a computer, or having a scribe record their answers. The other accommodations listed in the report (permitted in 27 states) were word lists, dictionaries, or glossaries. According to Rivera et al. (2000), a survey of state assessment directors for 1998-1999 found 21 states that allowed bilingual dictionary accommodations on reading tests; 11 of the 21 allowed them for all parts of the assessment.

Rivera, Vincent, Hafner, and LaCelle-Peterson (1997) noted that 52% of states reported that they allowed test modifications for ELL students on at least one statewide assessment. Extra time was the most frequent test modification reported by states. The North Central Regional Educational Laboratory (NCREL) also found that half of the states reported allowing accommodations for ELL students, including separate settings, flexible testing schedules, small-group administration, extra time, and simplified directions (Liu et al., 1997; NCREL, 1996a, 1996b). Some states, such as Arizona, Hawaii, New Mexico, and New York, used other languages for the test or an alternative test (Liu et al.).

The National Assessment of Educational Progress (NAEP) has been providing accommodation to some ELL participants for many years. In the NAEP field test in 1995, several accommodations for mathematics were provided for ELL students. Administrative procedures included extra testing time, modifications in the administration of sessions, and facilitation in the reading of directions. Also, Spanish-English bilingual assessment booklets, with items in different languages presented on facing pages, and Spanish-only assessment booklets were available. Most ELL students chose to take the Spanish version. The results indicated that the translated versions of some items might not have been parallel in measurement properties to the English versions (Olson & Goldstein, 1997).

The NAEP 1996 tests were designed with three samples of schools, using the 1996 inclusion criteria in the second and third samples and having assessment accommodations available in the third sample. ELL students were permitted some of the accommodations—one-on-one testing, small-group testing, extended time, oral reading of directions, use of magnifying equipment, and the use of an individual to record answers—plus a Spanish/English glossary of scientific terms. Students using the glossary were usually given extra time. Very few ELL students used the glossary provided (O'Sullivan et al., 1997).

Many different forms of accommodation—some of which have shown promising results—have been documented (see Abedi et al., 1998; Castellon-Wellington, 2000; Liu, Anderson, Swierzbin, Spicuzza, & Thurlow, 1999; Liu, Anderson, Swierzbin, & Thurlow, 1999; Mazzeo, 1997; Miller, Okum, Sinai, & Miller, 1999; Olson & Goldstein, 1997). However, some accommodation strategies that have demonstrated effectiveness may not be the most feasible accommodations. For example, an accommodation consisting of testing one-on-one was used in NAEP assessment (see Mazzeo). This form of accommodation—among others that were used in NAEP main

assessment—increased the level of inclusion of students with limited English proficiency. However, one-on-one testing is neither space-, time-, nor cost-efficient enough to be a feasibility favorite in large-scale assessments.

Methods

Instrumentation

Math Tests. Math tests were assembled for Grade 4 and Grade 8 students using a combination of NAEP (1996) and TIMSS (1994-5) public release items.[6] Two forms of math tests were constructed: Form A and Form B. The two forms had the same math items, but in different locations. Thus, having two test forms allowed us to examine the difficulty level of test items at different locations. It also helped to deter cheating. Items were selected to test a range of content areas with a varied range of language demand. Tables A3 and A4 show the distribution of content areas covered in each math test. Tables A5 and A6 show the variation of linguistic complexity among the items (see Appendix A). Each math test was made into a computer version as well.

Reading proficiency tests. A reading measure is an essential part of the accommodation study since students at different levels of reading proficiency may benefit differently from the accommodations used in the study. A battery of English reading proficiency tests were chosen for this study to measure student levels of reading proficiency. The battery included the fluency subscale of Language Proficiency Scales (LAS) (to provide a good distribution among various levels of ELL students), a NAEP reading block, and a CRESST-devised test of English word recognition. CRESST researchers have already examined the content coverage of some commonly used English language and literacy tests. (See Abedi, Courtney, Mirocha et al., 2000; Imbens-Bailey, Dingle, & Moughamian, 1999.) All sections were administered within rigid time restrictions.

Accommodation follow-up questionnaire. This brief feedback gathered students' opinions of the math test and accommodations—and on math tests and test accommodations in general.

Background questionnaire. The background questionnaire included questions on student background characteristics, such as gender and ethnicity. The questionnaire also included questions pertaining to students' language background, such as length of time in the United States, language other than English spoken in the home, and country of origin.

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[6] The Third International Mathematics and Science Study (TIMSS).

Teacher and school questionnaire. Teacher and school questionnaires were administered. The teacher questionnaire included questions regarding teachers' educational background and experience as well as the teachers' teaching of science and use of accommodation in the classroom. The school questionnaire included questions about school population and resources.

Sample and Design

Classes of students in Grades 4 and 8 in a single urban public school district in Southern California were tested in math and reading on 2 consecutive days. In Grade 4, 666 students participated; 304 of them English language learners (ELLs) classified as limited English proficient (LEP). In Grade 8, of the 643 participants, 290 of them were classified as LEP. Of the 1,309 total student participants, 594 were classified by their schools as LEP. A total of 29 Grade 4 and 27 Grade 8 classes participated from 9 elementary schools, 7 middle schools and 1 K-12 newcomer school (see Tables A1 and A2).

We examined the test results and questionnaires from a net total of 607 students in Grade 4 and 542 students in Grade 8.[7] The minimum number of subject per cell was calculated through a power analysis (see Kirk, 1995, pp. 60-64) using the variance that was obtained in an earlier, similar CRESST accommodations study (Abedi et al., 1998). This number of subjects has proven to be sufficient for the analytic work needed for research and policy purposes. We analyzed the results of 1149 participants in this study.

In Grade 4, of the net total of 607 students, 279 or 46% were ELL students and 328 or 54% were non-ELL students. Of the net total of 542 Grade 8 students, 256 students (47%) were ELL students and 286 (53%) were non-ELL students. Four different forms of accommodation were administered to Grade 4 students and two forms for Grade 8. A control or comparison group was included in the study to measure the effectiveness of accommodation strategies. In addition to a comparison group that received no accommodation, non-ELL students were sampled in this study to serve as another control or comparison group to determine the impact of accommodation on the construct under measurement.

[7] A small number of participants were excluded from the study because they were completely non-English-speaking or were absent on one of the two days of testing. In addition, when accommodated results were compared, the scores of the 20 small-group participants were excluded.

For Grade 4, five accommodation conditions were used: (a) customized English dictionary, (b) small-group testing, (c) extended time, (d) computer testing, and (e) no accommodation. This generated 10 cells for Grade 4 students: five accommodation conditions for ELL students and five for non-ELL students.

For students in Grade 8, the extension of testing time and small-group testing were excluded from the accommodation. For this grade, the accommodations were: (a) customized English dictionary, (b) computer testing, and (c) no accommodation. Thus, for Grade 8, we generated 6 cells.

The timing of the test allowed extra assessment time in order for students assigned an accommodation to make use of the customized English dictionary or the computer test's pop-up glossary. To absorb their extra time, students who did not receive an accommodation were given a word list and asked to check off which test words were difficult to understand.

Customized English dictionary. This is the second CRESST study to use a customized English dictionary as an accommodation. This tool simulates the look and full entries of a dictionary without the bulk of the entire text or the unfair advantage of providing definitions for terms and concepts being tested. To the left of each entry is a circle for students to check if they looked up that word.

Computer testing with a pop-up glossary. In contrast, the concise computer glossaries created for this study provide the simplest and most item-appropriate synonym for each difficult non-science word in the test (see Figure 1). Students who

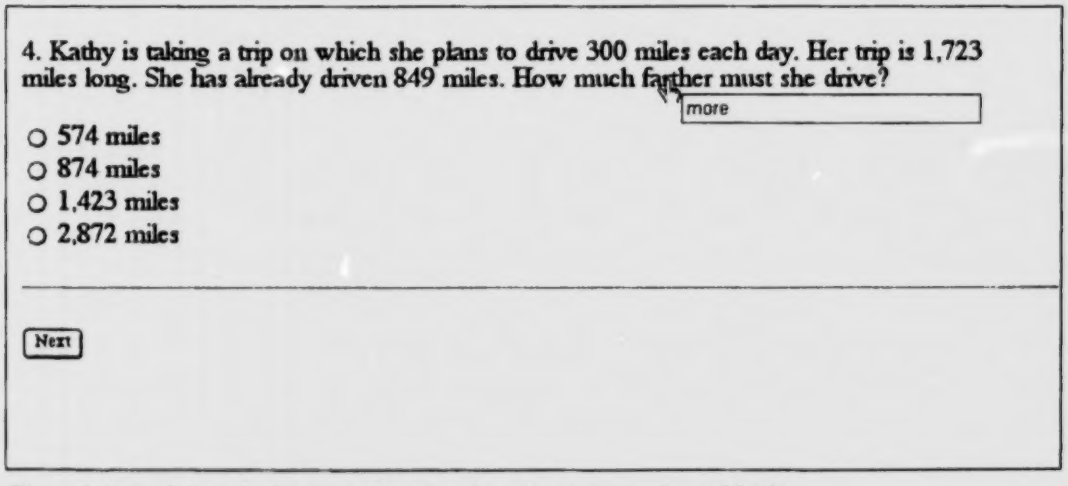
4. Kathy is taking a trip on which she plans to drive 300 miles each day. Her trip is 1,723 miles long. She has already driven 849 miles. How much farther must she drive?
more
574 miles
874 miles
1,423 miles
2,872 miles
Next

Figure 1. A math item in the computer test, showing pop-up gloss of *farther*.

took the computer version of the math test had access to a "pop-up glossary," a feature that provided a simple gloss of a word with the touch of the (mouse) pointer. The program timed the length of time students spend on each test item and the time that the gloss appeared on the screen.

Small-group testing. Four to 7 students were tested at once in a separate room, usually a quiet school library.

Testing with extra time. Eight intact Grade 4 classes were tested with extra time for completing the math test.

Distributing Grade 4 accommodations. If computer testing was possible, 1 to 4 ELL students were randomly selected for that accommodation, as were 1 to 4 non-ELL students. Where small-group testing was possible, 4 to 7 students (just over half ELLs) were randomly selected for that accommodation. Their classmates remained in their classroom, and 50% to 60% of them (a fairly even mixture of ELL and non-ELL students) were randomly given a glossary called a customized English dictionary with the math test. The remaining students were given a list of the same words, unglossed. Eight of the Grade 4 classes received an accommodation of extra time, but no customized dictionary.

While 3 of the participating elementary schools had no Internet capability at the time, 14 classes in 6 of the schools had the facilities to host the computer version of the tests, in most cases a quiet room. Only 4 elementary schools had the space to accommodate small-group testing.

Of the 607 Grade 4 participants, 157 (25.9%; 64 ELL, 93 non-ELL) were assessed under the customized dictionary condition, 20 (3.3%; 11 ELL, 9 non-ELL) with small-group testing, 173 (28.5%; 89 ELL, 84 non-ELL) with extended time, and 79 students (13%; 35 ELL, 44 non-ELL) with computer testing. Testing under the standard (non-accommodated) condition were 178 participants (29.3%; 80 ELL, 98 non-ELL). The totals analyzed in each accommodation group are listed again in Table 1.

Distributing Grade 8 accommodations. If computer testing was possible, one to 16 ELL students were randomly selected for that accommodation, as were one to 11 non-ELL students.[8] Their classmates remained in their classroom, and 50% to 60%

[8] Some classes contained only ELL or only non-ELL students. One large group of ELL students was split into two groups for computer testing to keep the group size to 11 or less.

Table 1

Number of Students Tested Under Different Forms of Accommodation by ELL Categories

Type of accommodation/grade	Total	ELL	Non-ELL
Grade 4			
Customized dictionary	157	64	93
Small-group testing	20	11	9
Extended time	173	89	84
Computer testing	79	35	44
No-accommodation	178	80	98
Total	607	279	328
Grade 8			
Customized dictionary	173	86	87
Computer testing	152	84	68
No-accommodation	217	86	131
Total	542	256	286

of them were given a glossary called a customized English dictionary with the math test. The remaining students were given a list of the same words, un-glossed.

While 3 of the participating middle schools had no Internet capability at the time, there were 20 computer-testing groups in 7 of the schools. We tested between 5 and 11 Grade 8 students at a time on the computer version of the tests.

Of the 542 Grade 8 participants, 173 students were assessed under the customized dictionary condition (32%; 86 ELL and 87 non-ELL), 152 with computer testing (28%; 84 ELL and 68 non-ELL), and 217 were tested under the standard (no accommodation) condition (40%; 86 ELL and 131 non-ELL). The totals analyzed in each accommodation group are shown above in Table 1.

Test Administration

Test administrators followed a script so that all study participants received the same instructions. The tests included instructions and samples of multiple-choice and open-ended questions. Where glossaries were administered, the students were asked to find and mark a particular word in the customized dictionary or (if non-accommodated) in the word list. Most of the testing occurred in the students' regular classroom. The few small-group-testing sessions were held in a library or

resource room. We conducted computer testing in a library, a computer lab, or a classroom—usually separate from the rest of the class.

The math test administration of the customized dictionary and standard (non-accommodated) conditions had the same allotment of time, 40 minutes for Grade 4 and 30 minutes for Grade 8. The Grade 4 math testing with extra time was allotted 60 minutes, but few students took advantage of the extra time. Reading tests, whether on paper or computer, were given without extra time. The computer and small-group conditions were administered with extra time, except where middle school or school bus schedules did not permit.

Computer testing. Computer testing was given in a variety of locations on one of three types of computers. The best computer test situation was a set-up with CRESST's PC laptops (using the Internet Explorer browser) in a quiet lab or library. This created the most uniform look and behavior of the tests and pop-up glossary for all students. Additionally, the data came across to the server without being affected by school computers' idiosyncratic settings.[9]

Questionnaire Administration

In most cases, the accommodation follow-up questionnaire was administered immediately after the math test. The student background questionnaire was administered during a time convenient to the testing schedule. Usually, the student background questionnaire was filled out during the first testing visit, checked by the test administrators for consistency and completeness, and, as needed, was corrected by the student on the second visit.

The test and questionnaire data were scanned into a database and verified using the TELEform software. The scanned entry of every student ID on each of the four instruments was verified.

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[9] The second-best platform was using a school's PCs (loaded with Internet Explorer), with each display set to 800 x 600 pixels, and with auto-complete turned off. A less test-friendly computer set-up was when we used schools' Macintosh computers—especially those with older or un-compatible Web browsers. In some cases, we were not able to use existing computer labs because the school's computers' small memory capacity made the test pages and their images load too slowly. While many schools had Internet access in a quiet lab or a library, the worst testing environments were in "the classroom where the computers worked." In these cases, the room host lectured to a history class while our participants took their tests. We were pleased with the participants' ability to focus on the computer test.

Rating Open-Ended Items

The Grade 4 and 8 math and reading tests included open-ended items. The students' answers were rated by trained, degreed personnel whose work was checked for interrater reliability. NAEP scoring rubrics were used for both math and reading tests. The training encouraged raters to score only the substantive content of the responses only to the extent possible (rather than consider the composition, grammar, spelling, or punctuation). In other words, efforts were made to rate items based on the rubric (the evidence of reading comprehension or mathematical understanding in each response), not on the fluency of the English prose. Any retraining focused on agreeing how to interpret the rubric.

For 10% of the tests, two raters rated each open-ended item separately. The interrater reliability indices included percent of exact and within one point agreement, Product Moment correlation, intra-class correlation, kappa coefficient, and Williams' index or rater consistency. Computation of interrater reliabilities was performed through the use of Inter-rater Test Reliability System (ITRS). (For a discussion of ITRS and different interrater reliability indices, see Abedi, 1996.) After these responses were double-rated, interrater reliabilities were calculated. Raters were given additional rubric training for items with low reliability statistics. Once interrater reliabilities were proven to be satisfactory, a single rater then scored the remainder of the items.

Grade 4 math test. All items showed high interrater consistency (reliabilities ranging from .810 to .981). Table 2 presents a summary of the interrater reliability analyses for the Grade 4 open-ended math items.

Grade 4 reading test. There was more variability in the interrater reliabilities for the reading test items than the interrater reliabilities for the math test items (kappas ranging from .667 to .984). See Table 2 for reliability summaries for the Grade 4 open-ended reading items.

Table 2

Grade 4 Results of Interrater Reliability Studies for Open-Ended Test Items

Item #	# Students	Kappa	% Agreement
Math 13A/19B	120	.981	99.17
Math 14A/20B	124	.851	92.74
Math 26A/27B	111	.810	86.49
Math 27A/26B	118	.950	96.61
Reading 1	124	.984	99.19
Reading 6	110	.890	98.18
Reading 8	104	.881	96.15
Reading 10	93	.667	84.95

Grade 8 math test. Equivalent scoring and training procedures were provided for rating the Grade 8 math items. Again, after all responses for the first 10% of the students were rated, interrater reliabilities were calculated. All the math items showed high to perfect interrater consistency (reliabilities ranging from .854 to .990). Many students left the more difficult items blank, which explains why some of the numbers are small. None of the "blank" responses were included in the interrater reliability analyses. Table 3 presents a summary of the interrater reliability analyses for the Grade 8 open-ended math items.

Grade 8 reading test. Generally, the interrater reliabilities for the reading test items were lower (kappas ranging from .708 to .942) than for the math test items, with one item posing considerable difficulty for the raters (kappa = .529). See Table 3 for reliability summaries for the Grade 8 open-ended reading items.

Rating of Items for Linguistic Complexity

Our previous studies have clearly shown that linguistic complexity of content-based test items negatively impacts the performance of ELL students (see for example, Abedi et al., 1997; Abedi, Courtney, & Leon, 2001; Abedi & Lord, 2001). To examine such an effect and to control for linguistic complexity of math test items, individual test items were rated for linguistic complexity.

The linguistic complexity rating was based on the rubric developed in our earlier studies (Abedi, Courtney, Mirocha, et al., 2001). These ratings are composites from the scores given by two college instructors of English grammar. A 5-point

Table 3

Grade 8 Results of Interrater Reliability Studies for Open-Ended Test Items

Item #	# Students	Kappa	% Agreement
Math 16A/21B "Estimate"	91	1.000	100.00
Math 16A/21B "Explain"	71	.854	95.77
Math 20A/34B	47	1.000	100.00
Math 22A/20B	113	.968	98.23
Math 24A/22B	71	1.000	100.00
Math 25A/17B	47	.956	97.87
Math 35A/35B	12	1.000	100.00
Reading 1	131	.922	96.18
Reading 2	121	.708	89.26
Reading 3	105	.763	85.71
Reading 4	71	.529	74.65
Reading 6	82	.942	96.34
Reading 9	55	.808	89.09

Likert scale was used for rating linguistic difficulty of the items (0 being less linguistically complex to 4 being very complex). (A rating for each math item is found in Table A5 for Grade 4 and in Table A6 for Grade 8 items.) We combined items into two categories, less complex (0, 1, and 2) and more complex (3 and 4). We created two testlets accordingly. We examined the hypotheses of effectiveness and validity separately for each testlet.

We looked at how accommodation effect varied between the two testlets by performing a multivariate analysis of covariance in order to assess whether the significant accommodation effect found in the total score was due to the complexity of the item.

Math performance of ELLs and non-ELLs was also compared using analysis of variance. The results will be discussed in the next chapter.

Psychometric issues concerning English reading proficiency tests. Both classical and modern test theories discuss the issues concerning the impact of test length on reliability of the entire test. For example, in classical test theory, "as a general rule, the more items in a test, the more reliable the test" (Salvia & Ysseldyke, 1998, p. 149), assuming test items are unidimensional. Similarly, in Generalizability (G) Theory, when test items as a facet of a G study have a substantial contribution to

the measurement error in terms of both relative and absolute decisions (see Shavelson & Webb, 1991), then increasing the number of items reduces the source of error due to test items. One can expand the concept of test length to multiple outcome measures. A single outcome measure may not be as reliable as a composite of several outcome measures assuming unidimensionality of the components. This may be more evident in areas where complex measurement is taken.

The literature is clear on the lack of a single reliable and valid measure of English reading proficiency (see for example, Abedi, Courtney, & Leon, 2001). For example, the most commonly used English language proficiency tests may not have enough discrimination power to be used as a single measure of English proficiency. On the other hand, other tests of English language (measures of language arts such as reading, writing, and vocabulary) may be more difficult for ELL students in the lower part of the English language proficiency distribution. Therefore, the score distribution of English language measures may be either highly skewed to the left (positive skew, being difficult for lower performing kids) or highly skewed to the right (negative skew, lack of enough discrimination power).

A solution to this problem is to provide multiple measures of English reading proficiency and create a composite of scores. The composite score is obtained through a simple composite approach by averaging the scores after adjusting for scale differences. If the score components are highly correlated (.80 and above), this is a reasonable approach. However, if the components are not highly correlated, then a latent-variable modeling approach is more appropriate. A latent composite is then used as a covariate, for example, in the analyses comparing accommodated and non-accommodated performance.

In this study we obtained multiple measures of students' English proficiency. Composites of these measures were obtained in both ways, simple and latent-composites. Figure 2 presents a model of a composite English measure. As Figure 2 shows, the reading latent variable is defined as the common variance among three measures: (a) LAS fluency section, (b) NAEP open-ended reading comprehension questions, and (c) NAEP multiple-choice reading questions. To estimate the validity of the latent composite, it was correlated with the NCE (Normal Curve Equivalent) scores of the Stanford 9 (SAT9) test. Table 4 summarizes some of the results of this analysis. As Table 4 shows, the correlation between the reading SAT9 and the simple reading composite was .675. The correlation between the SAT9 and reading increases slightly to .698 when the SAT9 scores are correlated with the latent reading

composite. For math, correlation between SAT9 and simple math composite (.566) is identical with the correlation between the SAT9 and the latent composite (.566).

To be used as an effective covariate, a variable must be highly correlated with the outcome variable. We computed the correlation between the simple math composite and the simple English reading composite (r = .558) and we compared it with the correlation between the two latent composites (math and reading) (r = .559). Since the data did not show much difference between the simple and latent composite in this case, we used the simple composite in our analyses and reported it because it is easier to report.

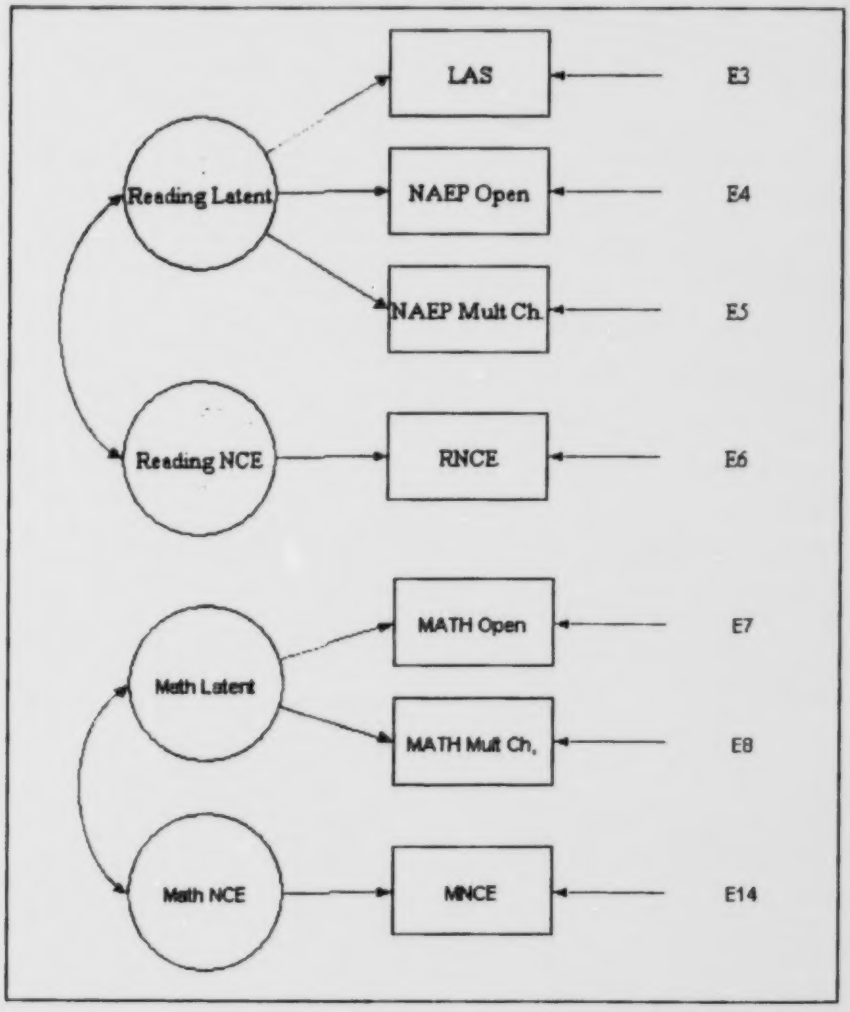

Figure 2. Latent variable diagrams.

Table 4

Pearson Correlations: Stanford 9 Normal Curve Equivalents With Total Test Raw Scores and Latent Factor Scores

	Test raw scores		Latent factor scores	
	Reading	Math	Reading	Math
Reading SAT9	.675 (n = 427)	.579 (n = 427)	.698 (n = 427)	NA
Math SAT9	.479 (n = 420)	.566 (n = 420)	NA	.566 (n = 420)

Results

To examine the effectiveness and validity of accommodations for ELL students, sampled students in Grades 4 and 8 were observed under different forms of accommodation, and under a control condition where no accommodation was provided. The purpose of this study was to test the three main research hypotheses, each related to one of the issues related to accommodation. They were: (1) effectiveness, (2) validity, and (3) feasibility. The accommodation plan was slightly different for the two grades. As indicated earlier, Grade 4 students were assessed under four different accommodation strategies (computer testing, extra time, customized dictionary, and small-group testing), as well as under a standard condition where no accommodation was provided. However, Grade 8 students were tested under two accommodations (computer testing and customized dictionary) and under the standard condition. Because of such a difference among accommodation conditions across the two grades, we report the findings separately for the two grades. The research questions for this study are:

- Which test accommodations are more effective in reducing the gap in performance between ELL and non-ELL students? (effectiveness)
- Do the accommodations impact the validity of the assessment (i.e., change the content of the assessment)? (validity)
- Are the accommodations that reduce the performance gap between ELL and non-ELL students (without altering the construct) easily implemented? (feasibility)

Results for Grade 4 Students

Effectiveness. We tested ELL and non-ELL students in Grade 4 under five conditions: four different accommodations and a standard condition. Students tested under the standard condition served as a control group. We also studied non-ELL students under the five conditions to provide data for examining the validity of accommodations used in this study. A comparison among the math mean scores of ELL students receiving different forms of accommodation with the mean scores of ELL students under the standard condition provides evidence on the effectiveness of the accommodations for ELL students. Those accommodations that help students perform significantly higher than the standard, no-accommodation condition are labeled as effective. The higher the difference between the accommodated and non-accommodated performance, the more effective is the accommodation.

Table 5 presents the means, standard deviations, and numbers of students for each of the five conditions (four accommodations and the standard condition). As the data in Table 5 show, a total of 279 Grade 4 ELL students were tested under the five conditions. Because there were limits to how many we could test simultaneously on computers, a smaller number of students were tested under this condition (n = 35). The mean score for students under the computer accommodation was 14.69 (SD = 5.12, n = 35); under the extra time accommodation, the mean was 13.74 (SD = 6.02, n = 89); under the customized dictionary accommodation the mean was 13.81 (SD = 6.04, n = 64); under the small-group accommodation, the mean was 9.55 (SD = 2.88, n = 11); and under the standard condition, the mean math score was 12.27 (SD = 5.24, n = 80). As these data suggest, students in Grade 4 performed better under most forms of accommodation that were provided in this study. However, the data also is clear that students benefited more from some forms of accommodation than others. For example, students taking the computer test obtained 2.42 score points (about a half standard deviation) higher than students under the standard condition. This difference becomes smaller with the other accommodations. The difference in student performance under extra time and standard condition was 1.47 (about a quarter standard deviation). For the customized dictionary, the difference was 1.54 (about a quarter standard deviation), and for small-group testing, the difference was 2.72.

The data in Table 5 suggest that students performed better under all accommodation conditions except small-group testing. Since the number of students who participated in small-group testing was very small, descriptive statistics for this accommodation may not be reliable; therefore, further analyses were not performed on the data from this accommodation.

These accommodations are considered effective if the difference in performance is statistically significant. We randomly assigned students to the different accommodation conditions (8 groups, 4 ELL and 4 non-ELL). However, in spite of randomization of students to the 8 accommodation conditions, initial English proficiency differences may exist. If so, a significant difference between accommodated and non-accommodated conditions may be due to such initial differences. That is, students testing under a high-scoring accommodation condition may have belonged to a higher (math) performance group with higher level of English proficiency. To adjust for any initial difference in the level of English proficiency, the reading total score (LAS subscale score plus multiple-choice and

Table 5

Raw Score Grade 4 Math Means for ELL Students

Accommodation	*N*	Mean	Std. dev.
Computer	35	14.69	5.115
Extra time	89	13.74	6.024
Cust. dictionary	64	13.81	6.043
Small-group testing	11	9.55	2.88
Standard condition	80	12.27	5.242
Total	279	13.44	5.719

open-ended NAEP reading scores) was used as a covariate. The differences among the adjusted means under the accommodated and the standard conditions were tested for statistical significance. Table 6 presents the results of these comparisons.

The half standard deviation difference (between computer testing and the standard condition) in Table 5 was tested for statistical significance. The results in Table 6 show this difference was significant at the .005 nominal level, well beyond the .01 nominal level. To show the magnitude of effects, we also computed the coefficient of determination, η^2, the percent of variance explained. For the effectiveness of the computer testing condition, η^2 was .030, suggesting that this accommodation affected the math performance of about 3% (explaining 3% of the variance of the math score).

For extra time, the difference between accommodated and non-accommodated ELL students was also significant at the .01 nominal level. For this comparison, η^2 was .024, which explains about 2.4% of the variance of math scores. For the customized dictionary, the difference between the ELL students' accommodated and non-accommodated performance was not statistically significant.

Thus, the results of analyses for students in Grade 4 suggest that computer testing and testing with extra time were effective forms of accommodation.

Validity. To consider an accommodation strategy for use in NAEP, it must be effective *and* valid. An accommodation is valid if it does not change the construct under measurement; that is, if it does not increase the performance of non-ELL students. To test the validity of accommodations, non-ELL students were also tested under the five different accommodation conditions. Table 7 presents descriptive statistics including the mean, standard deviation, and number of students for each of

Table 6

Grade 4 Math Means for ELL Students Adjusted by Reading Scores

Accommodation	*N*	Adj. mean	Std. err.	Sig.
Computer	35	14.922	.805	.005
Extra time	89	14.037	.506	.012
Cust. dictionary	64	13.372	.597	.138
Small group	11 (NA)	NA	NA	NA
Standard condition	80	12.182	.533	

Note. Each student's reading score was used as a covariate.

Table 7

Raw Score Grade 4 Math Means for Non-ELL Students

Accommodation	*N*	Mean	Std. dev.
Computer	44	16.45	5.626
Extra time	84	16.47	6.296
Cust. dictionary	93	17.46	7.033
Small group	9	15.56	6.564
Standard condition	98	17.38	6.947
Total	328	17.00	6.617

the five accommodation conditions for non-ELL students. Comparing the mean math score under the accommodations with the mean under the standard condition, one may not see any improvement in students' performance due to accommodations. For the computer testing, the mean math for non-ELL students was 16.45 (SD = 6.63, n = 44); for extra time, the mean was 16.47 (SD = 6.30, n = 84); for the customized dictionary, the mean was 17.46 (SD = 7.03, n = 93); and for small-group testing, the mean was 15.56 (SD = 6.56, n = 9); compared to a mean of 17.38 (SD = 6.96, n = 98) for the standard (non-accommodated) condition.

To control for existence of any initial differences between groups, we adjusted each mean math score by the student's level of English proficiency using a reading score composite as a covariate. While the differences between the accommodated and standard (non-accommodated) conditions did not seem to be large, we tested these differences for statistical significance. Table 8 shows the results of inferential tests comparing non-ELL, accommodated performance with non-ELL, non-accommodated performance. To control for the Type I error rate, the pooled-within-

Table 8

Grade 4 Math Means for Non-ELL Students—Adjusted by Reading Scores

Accommodation	*N*	Adj. mean	Std. err.	Sig.
Computer	44	16.295	.822	.262
Extra time	84	16.550	.595	.292
Cust. dictionary	93	17.435	.565	.971
Small group	9 (NA)	NA	NA	NA
Standard condition	98	17.406	.550	

Note. Each student's reading score was used as a covariate.

group variance was used in a set of a planned multiple *t*-tests. These analyses were performed on the adjusted scores.

As the data in Table 8 suggest, none of the differences were statistically significant. That is, non-ELL students performed the same under the accommodated and standard (non-accommodated) conditions. These results are encouraging since they suggest that the accommodations that were found to be effective for students in Grade 4 are also valid because they did not affect the construct (math performance).

Feasibility. The feasibility of each accommodation was determined by the test administrators' observations and the project staff's experience. A summary of the observation and experience by test administrators and project staff will be presented here.

The use of computer versions of the math tests required programming of the tests with the pop-up glossaries as well as administering the tests with computer equipment and access to the Internet. With the computer testing, the main obstacle was school access to the proper Internet wiring, computer memory, and Internet software. In some schools, there was not a quiet place for a group of students to take a computer test. Another consideration was student agility with aiming the mouse and with moving the scroll bar. Some students closed the test window accidentally.

The greatest logistical issue for the extra time accommodation was scheduling. Schools were reluctant to allow extra test administration time that borrowed from teaching time. A second challenge was keeping the test environment quiet when there were Grade 4 students who had turned in their tests before the extra time was over.

The project staff spent a substantial amount of time compiling appropriate glossaries for the paper and computer math tests. They worked with content specialists to make sure content-related terms were not glossed, and at the same time, they worked with students to make sure that all non-math terms needing glossing were glossed.

However, the lack of use of the customized English dictionary led us to look for evidence of lack of exposure to dictionary use. We found in the student background questionnaire that only 12 of the Grade 4 students (7.6%) provided with the customized English dictionary stated on the questionnaire that they had used "an English dictionary" in the classroom before (see Table 9). Looking at the responses of all the Grade 4 participants, only 55 students (9.1%) responded that they had used a dictionary in the classroom before. Similarly, when asked on the accommodation follow-up questionnaire which accommodations they would prefer, only 26 (16.6%) of the students provided with the customized English dictionary and 96 of the total Grade 4 students (15.8%) stated that they would like an English dictionary "to make it easier for me to understand math problems" (see Table 10). (See Appendix B for further accommodation follow-up questionnaire results.)

Results for Grade 8 Students

Effectiveness. Grade 8 students were assessed under the computer testing and customized dictionary accommodations as well as under the standard condition (no accommodation provided). Table 11 presents descriptive statistics including the mean, standard deviation, and number of ELL students for the accommodated and

Table 9

Grade 4 Background Question #5a - I Have Used an English Dictionary

	No		Yes		Total	
Accommodation	*N*	%	*N*	%	*N*	%
Computer	77	97.5	2	2.5	79	100.0
Extra time	155	89.6	18	10.4	173	100.0
Cust. dictionary	145	92.4	12	7.6	157	100.0
Small group	17	85.0	3	15.0	20	100.0
Standard condition	158	88.8	20	11.2	178	100.0
Total	552	90.9	55	9.1	607	100.0

Table 10

Grade 4 Follow-Up Question #2f - To Make It Easier to Understand Math Questions I Would Like an English Dictionary

	No		Yes		Total	
Accommodation	*N*	%	*N*	%	*N*	%
Computer	69	87.3%	10	12.7%	79	100.0
Extra time	148	85.5%	25	14.5%	173	100.0
Cust. dictionary	131	83.4%	26	16.6%	157	100.0
Small group	17	85.0%	3	15.0%	20	100.0
Standard condition	146	82.0%	32	18.0%	178	100.0
Total	511	84.2%	96	15.8%	607	100.0

Table 11

Raw Score Grade 8 Math Total Means for ELL Students

Accommodation	*N*	Mean	Std. dev.
Computer	84	10.17	4.361
Cust. dictionary	86	9.95	3.835
Standard condition	86	9.47	4.005
Total	256	9.86	4.065

standard (non-accommodated) conditions. As the data in Table 11 show, ELL students performed higher under both accommodations when compared to the performance under the standard condition. For the computer testing, the mean was 10.17 (SD = 4.36, n = 84); for the customized dictionary, the mean was 9.95 (SD = 3.84, n = 86); and for the standard condition the mean was 9.47 (SD = 4.00, n = 86).

To test the effectiveness of accommodations used for students in Grade 8, the mean math scores were compared across the accommodation conditions. In spite of a random assignment of students to the different accommodation conditions, their initial English reading proficiency may lead to math performance differences between the groups. Similar to the analytical approach used for Grade 4 data, we used a reading score composite as a covariate to control for possible initial differences among the 6 condition groups.

A series of planned comparisons were conducted on the adjusted means to compare student performance under the accommodated conditions with the performance

under the standard condition. Table 12 presents the results of these comparisons. As the data in Table 12 show, increased performance of ELL students under computer testing was significant beyond the .01 nominal level. However, the increased performance under the customized dictionary condition was not significant for these students. This suggests that computer testing is an effective accommodation for ELL students in Grade 8.

Validity. Table 13 presents descriptive statistics (mean, standard deviation, and number of students per group) for non-ELL students under the three accommodation conditions (computer testing, customized dictionary, and standard condition). As the data in Table 13 suggest, the means for the computer testing and for the customized dictionary are slightly higher than the mean math under the standard condition. For the computer testing, the mean was 14.76 (SD = 4.55, n = 68); for the customized dictionary, the mean was 14.12 (SD = 4.28, n = 87); compared to a mean of 13.94 (SD = 4.57, n = 131) for students tested under the standard condition.

Table 12

Grade 8 Math Total Means for ELL Students—Adjusted by Reading Scores

Accommodation	*N*	Adj. mean	Std. err.	Sig.
Computer	84	10.656	.408	.008
Cust. dictionary	86	9.838	.399	.197
Standard condition	86	9.108	.401	

Note. Each student's reading score was used as a covariate.

Table 13

Raw Score Grade 8 Math Total Means for Non-ELL Students

Accommodation	*N*	Mean	Std. dev.
Computer	68	14.76	4.547
Cust. dictionary	87	14.12	4.277
Standard condition	131	13.94	4.572
Total	286	14.19	4.474

Table 14 presents the results of planned multiple comparisons for non-ELL students. The adjusted mean math scores of non-ELL students under each accommodation were compared to the adjusted mean scores of non-ELL students

Table 14

Grade 8 Math Total Means for Non-ELL Students—Adjusted by Reading Scores

Accommodation	*N*	Adj. mean	Std. err.	Sig.
Computer	68	14.674	.491	.220
Cust. dictionary	87	14.205	.434	.623
Standard condition	131	13.930	.354	

Note. Each student's reading score was used as a covariate.

under the standard condition. As the data in Table 14 show, none of the comparisons were significant. That is, the two accommodation strategies did not affect the performance of non-ELL students. This suggests that the accommodations used in this study can be implemented without concerns about validity.

Feasibility. The feasibility of administering tests with a customized glossary and computer accommodations is possibly greater for Grade 8 students. (See Grade 4 results above.) Feasibility more likely increases with Grade 8 students because their exposure to dictionary and computer use may be greater, and their schools have more computers and more Internet access connections.

Accommodation Impact on Measurement With Degree of Linguistic Complexity

To examine the effect of accommodation and to control for linguistic complexity of math test items, individual test items were rated for linguistic complexity. The linguistic complexity rating was based on the rubric developed in our earlier studies (Abedi, Courtney, & Leon, 2001). A five-point Likert scale was used for rating linguistic difficulty of the items (0 being less linguistically complex to 4 being very complex). We combined items into two categories, less complex (rated 0, 1, or 2) and more complex (rated 3 or 4) and created two testlets accordingly. We examined the hypotheses of effectiveness and validity separately for each testlet.

In previous CRESST studies of linguistic demand of test items, the greater the language demand, the greater the gap in performance between ELL students and non-ELL students. For example, the findings of Abedi, Courtney, and Leon, (2001) suggest that there was more language demand in Grade 8 tests than in Grade 4 tests. To examine the relationship between ELL status and test item linguistic complexity, we performed multivariate analyses of variance with the linguistic complexity testlets serving as the outcome variables. The results indicate that for Grades 4 and 8, the ELL status was a stronger predictor of performance on the linguistically

demanding items. In Grade 4, the ELL status variable explained 7.8% of the variance for the linguistically demanding items, and only 4.5% of the variance for the less demanding items. In Grade 8, the ELL status variable explained 21.3% of the variance for the linguistically demanding items and only 9.3% of the variance for the less demanding items. This shows that there is more of a relationship between ELL status and linguistic complexity of items—again suggesting that linguistic complexity of Grade 8 test items create a larger hurdle for ELL students.

We looked at how accommodation effect varied between the two testlets by performing a multivariate analysis of covariance in order to assess whether the significant accommodation effect found in the total score was due to the complexity of the item.

We found that for Grade 4 ELL students, all the accommodations made a significant difference for the more linguistically complex items (computer, $p = .017$; extra time, $p = .027$; customized dictionary, $p = .049$). For the less complex math items, the computer and extra time accommodations were still significant. For non-ELL students, there were no significant accommodation effects; therefore, there were no validity issues for either of the two testlets.

For Grade 8 ELL students, we found that the computer accommodation was significant for the more linguistically complex items ($p = .001$), but it was not significant for the items that were less linguistically complex. For non-ELL Grade 8 students, there was no significant accommodation effect; therefore, validity was not a concern for either testlet.

Customized English dictionary use. Very few students marked circles to indicate that they had looked up words in the customized English dictionary. In Grade 8 classes, 140 of the 204 students with customized dictionaries marked the sample word they were asked to find. Otherwise a maximum of 4 students marked any given word, such as "growth," on the pages of definitions. In Grade 4 classes, 146 of the 170 students with customized dictionaries marked the sample word as instructed. Technical words such as "grid," "width," and "length" were looked up and marked by 8, 7, and 5 students, respectively. The lack of marked circles confirmed the test administrators' observations that most students did not use the customized dictionary or word lists after the first few attempts to look up a math word (which they did not find defined). In looking for evidence for lack of exposure to dictionary use, we found in the student background questionnaire that only 26

(15.0%) of the Grade 8 students provided with the customized English dictionary stated on the questionnaire that they had used "an English dictionary" in the classroom before (see Table 15). Looking at the responses of all the Grade 8 participants, only 78 students (14.4%) responded that they had used a dictionary in the classroom before. Similarly, when asked on the accommodation follow-up questionnaire which accommodations they would prefer, only 22 (12.7%) of the students provided with the customized English dictionary and 80 of the total Grade 8 students (14.8%) stated that they would like an English dictionary "to make it easier for me to understand math problems" (see Table 16). (See Appendix B for further questionnaire results.)

Computer pop-up glossary. Students taking the computer version of the math test had access to a "pop-up glossary," a feature that provided a simple gloss of words when students pointed to them with the mouse. The program timed the length of time students spent on each test item and the time that the gloss appeared

Table 15

Grade 8 Background Question #5a - I Have Used an English Dictionary

	No		Yes		Total	
Accommodation	*N*	%	*N*	%	*N*	%
Computer	124	81.6	28	18.4	152	100.0
Cust. dictionary	147	85.0	26	15.0	173	100.0
Standard condition	193	88.9	24	11.1	217	100.0
Total	464	85.6	78	14.4	542	100.0

Table 16

Grade 8 Follow-Up Question #2f - To Make It Easier to Understand Math Questions, I Would Like an English Dictionary

	No		Yes		Total	
Accommodation	*N*	%	*N*	%	*N*	%
Computer	129	84.9%	23	15.1%	152	100.0
Cust. dictionary	151	87.3%	22	12.7%	173	100.0
Standard condition	182	83.9%	35	16.1%	217	100.0
Total	462	85.2%	80	14.8%	542	100.0

on the screen. Tables 17-20 show the mean, *N*, and standard deviation of the number of words glossed and the time (seconds) spent glossing. The results in Grade 8 produced a larger difference between the glossing behavior of ELL and non-ELL students. ELL students in Grade 8 spent nearly three times as much time glossing, and glossed almost twice as many words as non-ELL students.

Table 17

Grade 4 Computer Glossary Words Glossed by ELL Status

	N	Mean	Std. dev.
ELL	35	17.51	10.337
Non-ELL	44	18.91	9.454
Total	79	18.29	9.815

Table 18

Grade 4 Computer Glossary Seconds Spent by ELL Status

	N	Mean	Std. dev.
ELL	35	65.6857	55.92315
Non-ELL	44	68.7045	52.25144
Total	79	67.3671	53.57817

Table 19

Grade 8 Computer Glossary Words Glossed by ELL Status

	N	Mean	Std. dev.
ELL	84	26.06	14.879
Non-ELL	68	15.74	9.973
Total	152	21.44	13.869

Table 20

Grade 8 Computer Glossary Seconds Spent Glossing by ELL Status

	N	Mean	Std. dev.
ELL	84	188.5952	206.34473
Non-ELL	68	65.8824	72.33185
Total	152	133.6974	171.67666

Accommodation Follow-Up Questionnaire

To examine students' level of interaction with the accommodations and their impressions of the usefulness of accommodations, a follow-up accommodation questionnaire was developed. It was administered immediately after the math test. Students received questionnaires appropriate to their assigned accommodation. However, most of the prompts and alternatives contained in each version of the questionnaire were the same. Table 21 lists the common prompts and response alternatives included in each of the accommodation follow-up questionnaires.

We will compare the responses of ELL students and non-ELL students on these questions. These questions were in different formats. Some of the response alternatives were in a Likert-scale format with different scale points (3-point,

Table 21

Questions Common to Each Type of Follow-Up Questionnaire, With Response Alternatives

1.	In the math test I did not understand:	1-no problem, 2-some words, 3-many words
2.	To make it easier to understand math problems, I would like:	a-easier words
		b-simpler sentences
		c-easier math problems
		d-math I learned
		e-more pictures
		f-an English dictionary
		g-a translation dictionary
		h-some words in my language
		i-all words in my language
		j-questions read aloud
		k-more time
3.	Most of these math problems were:	1-very easy, 2-easy, 3-hard, 4-very hard
4.	Taking the test with this accommodation was:	a-a little hard
		b-hard
		c-same as other math tests
		d-easy
		e-fun
5.	Did you want to look up words during the test?	1-no, 2-sometimes, 3-often
8.	Would you like your tests to be more like this one?	1-yes, 0-no

4-point, etc.), and some (lettered above) were in a dichotomous format (yes/no or selected/not-selected). For such latter comparisons, we used the group average.

For the Likert-scale question, this average is the mean of the scale points, and for the dichotomous response, it is the proportion of "yes" or "selected." For example, question 1 asked: "In the math test, I did not understand" and the alternatives were coded as: (1) "I had no problem understanding the math test," (2) "I had problems with some words or sentences," and (3) "I had problems with many words or sentences." Thus, the responses for this question range between 1 (the words were clear) and 3 (the words were difficult). A mean closer to 1 would suggest that students on average did not find the words difficult, and a mean closer to 3 would suggest otherwise.

On dichotomous questions, the mean for each possible response ranges between 0 (no/not selected as a response) and 1 (yes/selected). A mean closer to 1 suggests that most of the respondents said "yes" or selected that reply. A mean closer to 0 suggests otherwise.

Accommodation Follow-Up Questionnaire Results for Grade 4

Table B1 summarizes the results of descriptive statistics (mean and standard deviation) for the common set of the follow-up questions for Grade 4 students. In Table B1, for each of the 19 questions, the mean and standard deviations are reported for ELL, non-ELL, and for the total group of students. For example, for question 1, the overall mean, on a 3-point Likert scale, across all four accommodation conditions for ELL students was 1.77 (*SD* = .61), and for the non-ELL students the mean was 1.61 (*SD* = .57). These data suggest that ELL students in Grade 4 did not understand words in the math test more than non-ELL students. Within the four accommodations, the mean for ELL students ranges between 1.64 (*SD* = .59) for the extra time accommodation and 1.87 (*SD* = .66) for the customized dictionary accommodation. For non-ELL students, the mean ranges between 1.53 (*SD* = .51) for the computer accommodation and 1.73 (*SD* = .59) for the extra time accommodation. As these data suggest, there is not a big range among the means across the four accommodations in either ELL category.

Question 2 asks students to indicate a condition that would help them understand math problems better. For example, if easier words in the math test would make it easier for them to understand the math questions, students selected option 2a. The overall mean for ELL students in Grade 4 was .51 (*SD* = .50) and for

non-ELL students the mean was .47 (*SD* = 50). That is, 51% of ELL students and 47% of non-ELL students indicated that easier words would help them understand the math problems.

Data in Table B1 show trends similar to those explained above for questions 1 and 2a. Usually, ELL students asked for easier words and clearer (less complex) sentences. However, in most cases, the differences between the means of ELL students and non-ELL students are not large enough to suggest any major trend. To test the differences between the response patterns of ELL students and non-ELL students for statistical significance, a multivariate general linear model was used. Table B1 presents the results of these analyses. In this table, "L" stands for a significant LEP main effect at the .05 nominal level; "A" stands for a significant accommodation main effect; and "I" stands for a significant ELL/accommodation interaction. For example, "LI" for question 1 in Table B1 suggests two significant results; "L" indicates that the difference between the overall mean for ELL students and non-ELL students was significant; and "I" suggests that the interactions between ELL and accommodations were significant.

The results of significance testing reveal that in the math test, ELL students had difficulty understanding more words than did non-ELL students. More ELL than non-ELL students reported that an English dictionary, a translation dictionary, some words in their language, or all words in their language would help them with the math test. ELL students were more likely to report that reading the test questions aloud would make the math questions easier. Students who took the computer test were much more likely to report that taking the test was "fun" than students with the customized dictionary or standard condition. These students were also more likely to want "more tests like this one." Students who took the computer test or had extra time felt that more pictures would better help them understand the math questions. Students who took the computer test or had extra time were less likely to request a translation dictionary compared to students with the standard condition. Students who took the computer accommodation reported looking up more words during the test.

Accommodation Follow-Up Questionnaire Results for Grade 8

The same set of follow-up questions reported in Table B1 was used for Grade 8 students. Table B2 summarizes the results of descriptive statistics (mean and standard deviation) for the common set of follow-up questions for Grade 8 students.

The trend of results for Grade 8 students is similar to the trend reported for Grade 4. In general, ELL students in Grade 8 preferred easier words and less linguistically complex sentences. For example, the mean for question 1 for ELL students was 1.98 (*SD* = .68) compared to a mean of 1.72 (*SD* = .60) for non-ELL students. The mean within the ELL status designations ranges between 1.94 (*SD* = .80) for the standard condition and 2.02 for the customized dictionary (*SD* = .63). Within the non-ELL students, the means range between 1.69 (*SD* = .61) and 1.75 (*SD* = .56). Once again, as these data suggest, there were not major differences between the means for question 1 across the accommodation categories.

To test for the significance of the differences, comparisons were made using multivariate ANOVA. Table B2 identifies the significant results as "L" (significant LEP main effect), "A" (significant accommodation main effect), and/or "I" (interaction between ELL status and accommodation). On the math test, ELL students in Grade 8 had difficulty understanding more words than did non-ELL students. ELL students in Grade 8 were more likely to report that more pictures on the math test would make the problems easier to understand. This was especially true for ELL students who took the computer test.

More ELL than non-ELL Grade 8 students reported that an English dictionary, a translation dictionary, some words in their home language or all words in their language would help them with the math test. ELL students were less likely to report that the test they took was the same as other math tests.

Grade 8 students who took the computer test were much more likely to report that taking the test was "fun" than students with the customized dictionary or standard condition. These students were also more likely to want "more tests like this one." A higher percentage of students in Grade 8 who took the computer- and customized-dictionary-accommodated tests reported that the test was easy compared to those who took the standard condition test. Similarly, a lower percentage of those accommodated felt that the math test was hard. Students in Grade 8 who took the computer accommodation reported looking up more words during the test than those using the customized dictionary.

Highlights of Follow-up Questionnaires

We want to highlight results that compare computer accommodation with other forms of accommodation used in this study. We will discuss students' impressions of computer testing based on the accommodation follow-up

questionnaire data. In the discussion section we will then present a more comprehensive picture of the level of efficiency of this accommodation by linking data from the different sources including background, performance, and follow-up data.

For comparing the computer accommodation with other accommodations, we focus on the following questions:

- 4d. Taking the test with this accommodation was (1-easy)
- 4e. Taking the test with this accommodation was (1-fun)
- 5. Did you want to look up words during the test (1-no, 2-sometimes, 3-often)

For Grade 4 students, the mean for question 4d was .38. For this question, the closer the mean is to its maximum value of 1, the easier students feel it is to take the test under that accommodation. For non-ELL students, the mean was .45. These results indicate that in general, non-ELL students felt that taking the test with the computer accommodation was easy—more so than did ELL students. However, there is a substantial range among responses to this question within the categories of accommodations. For example, for ELL students, the mean for this question ranges between .24 (*SD* = .43) for the extra time accommodation and .59 (*SD* = .36) for the computer accommodation. That is, ELL students felt more comfortable taking the test under the computer accommodation than under any other accommodations. For the non-ELL students, the mean for the computer-accommodated students was .37 (*SD* = .49)—considerably lower than the mean of .59 for the ELL students, in spite of their higher overall mean.

For Grade 8 ELL students, the overall mean on this question was .28 (*SD* = .45), and for the non-ELL students, the mean was .24 (*SD* = .43). Within ELLs, the computer-testing mean was .29 (*SD* = .46) compared to a mean of .21 (*SD* = .41) under the standard condition. For non-ELLs, the mean for the computer testing was .30 (*SD* = .46) compared to a mean of .18 (*SD* = .39) for the standard condition. Comparing these means with the means for Grade 4 students suggests that, in general, students in Grade 4 felt more comfortable with the accommodations than students in Grade 8. However, computer testing was still among the preferred forms of accommodation for both ELL students and non-ELL students in both grades.

Question 4e asks if "taking the test with this accommodation was fun." The closer the mean of this question was to 1, the more students felt they had fun taking the math test under the computer accommodation. For Grade 4 ELL students, the overall mean for this question was .60 (*SD* = .49) compared to a mean of .53 (*SD* = .50) for non-ELL students. Comparing the overall means between ELL and non-ELL groups suggests that ELL students indicated they were having slightly more fun than the non-ELL students. However, there were large differences among the means across the accommodation conditions. For example, the mean for ELL students ranged between .51 (*SD* = .50) for the standard condition and .85 (*SD* = .36) for the computer condition—a substantially higher mean for the computer accommodation. This suggests that ELL students felt that they had more fun being tested with the computer test than under any other accommodation. This was also true for non-ELL students. Their mean for the computer testing was .84 (*SD* = .37) compared to a mean of .40 for extra time.

For Grade 8 students, the overall mean for ELL students was .29 (*SD* = .45) and for non-ELL students, the mean was .20 (*SD* = .40) indicating that accommodations used in this study were not considered fun. However, as in the case of Grade 4 students, there is a substantial gap among the means under different accommodations. For example, for the ELL students, the mean ranged between .18 (*SD* = .39) for the standard condition and .45 (*S D* = .50) for the computer accommodation. Similarly, the lowest mean for non-ELL students was .13 (*SD* = .34) under the standard condition, and the highest mean was .42 (*SD* = .50) for the computer testing condition. These results suggest that computer testing was fun for Grade 8 students.

Question 5 asks students if they wanted to "look up words during the test." Responses to this question included: 1 for "no," 2 for "sometimes," and 3 for "often." The overall mean for ELL students in Grade 4 was 1.56 (*SD* = .72) compared to a mean of 1.53 (*SD* = .72) for non-ELL students. That is, both ELL and non-ELL students indicated at about the same rate that sometimes they wanted to look up words during the test. However, once again, there are substantial differences across the accommodation subgroups. For example, within ELL accommodation categories, the mean ranges between 1.45 (*SD* = .57) for extra time and 1.91 (*SD* = .51) for the computer testing. Similar results were found for the non-ELL students. For non-ELL students, the mean ranged between 1.37 (*SD* = .60) for extra time and 1.95 (*SD* = .65) for the computer testing. For Grade 8 students, the overall mean for ELL students

was 1.75 (*SD* = .63), and for non-ELL students, the mean was 1.38 (*SD* = .52), which indicates that ELL students look up more words during the test than the non-ELL students.

Several points are readily noticeable from the follow-up data presented above regarding the new accommodation strategy, the computer testing. Following are a few highlights:

- ELL students (more than non-ELLs) felt more comfortable with computer testing as a form of accommodation (they felt the test was easy) than with any other accommodation used in this study.
- Both ELL students and non-ELL students indicated that computer testing was more (substantially more) fun than any other accommodation conditions used in this study, including the standard condition.
- ELL students and non-ELL students (more so with ELLs) indicated that they looked up words more often under the computer accommodation than with the customized dictionary.

Test administrators noted in their observations that students taking the computer version of the tests rarely seemed distracted while taking the test, and that, of the 246 students taking the computer version of the tests (123 ELLs; 123 non-ELLs), 66% of the non-ELL students had computers at home, compared to 49% of ELL students.[10] Understandably, more non-ELLs were observed using touch-typing in taking the computer test.

In summary, students who were tested under the computer accommodation (particularly the ELLs) indicated that testing under this accommodation was easy and more fun. This accommodation also makes all students (particularly ELLs) more inclined to look up more words that they would have with the customized English dictionary.

Results of the Background Questionnaire

Grade 4 student background questionnaire. Question 1 in the background questionnaire asks for the place of birth. Table 22 presents the results for this question. As the data in Table 22 show, the mean reading score for students who were not born in the United States was lower than the means for those born in the United States. This variable was used in a multiple regression (MR) model as one of

[10] Based on responses from 77% of the computer testing participants. Of the respondents, there is a wider gap: 89% of the non-ELLs used a computer at home; 66% of the ELLs did.

Table 22

Grade 4 Background Question #1 - Country of Birth

1. I was born in:	*N*	Reading mean	Std. dev.
Korea	7	10.29	6.396
Mexico	52	10.81	4.348
The United States	507	12.15	3.803
Other	36	11.67	4.640
Total	602	11.99	3.953

the predictors of math and reading. Significance testing data will be presented for this variable in the discussion of the MR analysis.

Table 23 presents the mean reading scores by the number of years students have lived in the United States. There was a trend of an increased reading mean by the increase in the number of years in the United States. For example, students with only 1 year in the U.S. had a reading mean of 8.29 (SD = 5.30) compared to the reading mean of 12.30 (SD = 3.73) for students who indicated that they have lived in the U.S. their entire life. This variable is related to the students' language background. The level of impact of this and other background variables on student performance in math and reading will be explained in the multiple regression (MR) section.

Table 24 summarizes the results of descriptive statistics for question 3 in the background questionnaire. Students were asked to report their starting grade in the

Table 23

Grade 4 Background Question #2 - Number of Years in the U.S.

2. I have lived in the United States:	*N*	Reading mean	Std. dev.
Less than 1 year	4	9.13	4.768
1 year	14	8.29	5.298
2 years	10	10.10	5.021
3 years	12	12.58	3.801
4 years	23	10.83	4.441
5-8 years	78	11.40	4.180
All my life	462	12.30	3.734
Total	603	11.99	3.950

Table 24

Grade 4 Background Question #3 - Starting Grade in U.S.

3. I started school in the United States in:	*N*	Reading mean	Std. dev.
Preschool	366	12.46	3.776
Kindergarten	163	11.80	3.675
1st grade	35	11.50	3.976
2nd grade	12	9.42	5.900
3rd grade	12	10.17	4.802
4th grade	16	7.03	4.117
Total	604	11.98	3.954

United States. Similar to the results presented above for question 2, there was an increasing trend of reading test scores by an early start in U.S. schools. For example, students who started in a U.S. preschool had a reading mean of 12.46 (SD = 3.78) compared to the mean of 7.03 (SD = 4.12) of students who very recently started in U.S. schools.

Table 25 shows descriptive statistics for reading scores by the availability of resources in school. There were differences in the mean reading scores by different types of resources. For example, students who reported access to the Internet had a relatively higher reading mean (M = 12.60, SD = 3.89) than those reporting access to a bilingual dictionary (M = 10.14, SD = 4.28).

Table 25

Grade 4 Background Question #4 - Resources Used in School

4. I have used these in my school: (Choose all that apply)	*N*	Reading mean	Std. dev.
English dictionary	487	12.29	3.742
Bilingual dictionary	66	10.14	4.277
Word processor on a computer	159	11.93	4.130
The Internet	165	12.60	3.892
Computer tests	135	11.34	3.821
In school tutor	69	11.16	4.042
After school tutor	84	10.96	3.817
Library	369	12.35	3.939

Table 26 shows descriptive statistics for reading scores by students' interest in having certain resources in school. There were differences in the mean reading scores by different types of resources. For example, students who wished for access to the Internet had a relatively higher reading mean (M = 12.32, SD = 3.78) than those wanting access to an English dictionary (M = 9.57, SD = 4.40).

In this study, we asked students to self-report their level of understanding of the teacher's directions since comprehension of the language of oral instruction is an essential part of student learning. The summary of data for question 6 that is reported in Table 27 supports the hypothesis that an inability to understand the teacher's directions may lead to poor learning and result in poor performance. The reading mean for students who indicated that they understand the teacher's directions was 12.28 (SD = 3.86) compared to a reading mean of 6.75 (SD = 3.31) for students who indicated that they did not understand the directions. It must be noted, however, that the large majority of students (451 or 75%) indicated that they understood the teacher's directions "very well," and only four students (less than 1%) mentioned that they did not understand the teacher's directions at all. Thus, a small n in (and insufficient comprehension of) some of these categories may make the results inconsistent.

Table 26

Grade 4 Background Question #5 – Resources Needed in School

5. I wish my classroom had: (Choose all that apply)	N	Reading mean	Std. dev.
English dictionary	55	9.57	4.407
Bilingual dictionary	178	12.10	3.967
Word processor on a computer	167	12.09	3.863
The Internet	282	12.32	3.784
Computer tests	77	10.03	4.375
In school tutor	108	11.63	3.464
After school tutor	89	11.46	3.607
Library	62	9.47	4.689

Table 27

Grade 4 Background Question #6 - Understanding Teacher Directions

6. I can understand my teachers when they give directions in English:	*N*	Reading mean	Std. dev.
Very well	451	12.28	3.846
Well	133	11.53	3.925
Not well	12	8.42	5.017
Not well at all	4	6.75	3.304
Total	600	12.00	3.947

Question 9 (as summarized in Table 28) in the background questionnaire asks students to indicate, in comparison to others, how they are doing in math this year. Among the response options, students could select an option that indicates difficulty in understanding what the teacher says. Of the total 584 students who responded to this question, 14 (2.4%) indicated that they could not understand the teacher. The reading mean for this small group of students was 6.57 (SD = 4.36). In the next response category, students indicated that they learn less math than other fourth graders. For this group, the mean was 10.12 (SD = 4.17, n = 70). The reading mean for the next response, "I am learning as much math as other fourth graders" was 12.57 (SD = 3.54, n = 323), and for the next response, "I am learning more math than many fourth graders," the mean was 12.20 (SD = 4.08, n = 177). As these data suggest, the higher the level of students' self-rating of their math learning, the higher the level of their English proficiency. This is, to some extent, indicative of the validity of students' self-reported data.

Table 28

Grade 4 Background Question #9 - Learning Math How Well This Year

9. How well are you learning math this year?	*N*	Reading mean	Std. dev.
I don't understand what the teacher is saying in English.	14	6.57	4.363
I am learning less math than many fourth graders.	70	10.12	4.165
I am learning as much math as other fourth graders.	323	12.57	3.504
I am learning more math than many fourth graders.	177	12.20	4.082
Total	584	12.02	3.951

Background question 10 (as summarized by Table 29) asks about the linguistic difficulty and content difficulty of the math test items. Students having difficulty with the language of test items had substantially lower performance than those who had difficulty with the content of the items. The mean for students expressing concern over the linguistic difficulty of test items was 10.11 (SD = 4.35, n = 107) compared to a mean of 12.32 (SD = 3.61, n = 277) for students who had difficulty with content. Students who complained that they were asked questions that they had not had the opportunity to learn also performed about the same as those who had difficulty with the content. For this group (lack of opportunity to learn), the mean was 12.44 (SD = 3.95, n = 183).

Students were also asked to report the language they spoke before going to school. For this question, there were two major response categories with a large n. The results are summarized in Table 30. Students who indicated that they spoke

Table 29

Grade 4 Background Question #10 – Main Complaint About Math Tests

10. What is your main complaint about math tests (such as the Stanford-9)?	*N*	Reading mean	Std. dev.
They are hard to read.	107	10.11	4.35
They are hard math problems to answer.	277	12.32	3.61
They ask about math I haven't learned yet.	183	12.44	3.95
Total	567	11.94	3.96

Table 30

Grade 4 Background Question #11 - Language Spoken Before Going to School

11. Before I started going to school, I spoke: (Choose all that apply)	*N*	Reading mean	Std. dev.
English	404	12.16	4.00
Chinese	4	8.00	5.77
Korean	10	7.90	5.58
Spanish	350	11.92	3.73
Other	39	13.76	4.25

English before going to school had a mean of 12.16 (SD = 4.00, n = 404). For students who spoke Spanish before going to school, the mean was 11.92 (SD = 3.73, n = 350). These results suggest that the language spoken prior to schooling does not have much impact on students' reading performance.

Table 31 shows a summary of descriptive statistics for question 12, the language currently spoken at home. Response categories with the number of students smaller than 10 were excluded. Students who indicated that they currently speak English at home had higher reading score means than those speaking other languages. For example, the reading mean for students living in primarily English-speaking homes was 12.36 (SD = 3.89, n = 274) compared to a mean of 11.64 (SD = 3.82, n = 288) for students who speak Spanish at home. (This variable has been used in our previous studies as a proxy for English learners when an ELL designation code was not available.)

In background questions 13, 14, and 15, students who speak a language other than English at home were asked to indicate how well they speak, read, and write that language. Tables 32 through 34 present a summary of responses to these questions in relation to the students' reading scores. These questions are important since they examine the possible relationship between students' primary language with their proficiency level in English. As the data show, there seems to be a relationship between the level of students' proficiency in their primary language—at least in speaking and reading—with their level of proficiency in English. For example, students who indicated that they speak the other language "very well" had

Table 31

Grade 4 Background Question #12 - Language Spoken at Home Now

12. Now, at home, we mostly speak:	*N*	Reading mean	Std. dev.
English	274	12.36	3.89
Chinese	1	13.00	
Korean	8	9.50	6.33
Spanish	288	11.64	3.82
Other	21	11.90	5.16
Total	592	11.96	3.96

Table 32

Grade 4 Background Question #13 - I Can Speak My Non-English Language

13. I can now speak that language:	*N*	Reading mean	Std. dev.
Very well	183	12.01	3.96
Well	119	11.18	3.84
Not well	12	10.63	5.16
Not well at all	3	9.67	6.51
Total	317	11.62	3.99

a mean reading of 12.01 (SD = 3.96, n = 183), the highest mean. The next highest mean was for those students who said that they speak the other language "well." For these students, the mean was 11.18 (SD = 3.84, n = 119). For the "not well" response category, the mean was 10.63 (SD = 5.16, n = 12), and for the "not well at all" response, the mean was 9.67 (SD = 6.51, n = 3). For the last two categories in Table B11, however, the n was small and the means may not be stable enough across cross-validation samples.

Table 33 shows the mean reading scores across the categories of how well the student reads the language other than English. As the data in Table 33 show, the higher the level of student confidence in reading the primary language, the higher the level of English reading proficiency.

Table 34 shows responses to self-reported proficiency in writing the primary language in relation to the students' English reading scores. Unlike the data

Table 33

Grade 4 Background Question #14 – I Can Read My Non-English Language

14. I can now read that language:	*N*	Reading mean	Std. dev.
Very well	183	12.01	3.957
Well	119	11.18	3.835
Not well	12	10.63	5.157
Not well at all	3	9.67	6.506
Total	317	11.62	3.992

Table 34

Grade 4 Background Question #15 - I Can Write My Non-English Language

15. I can now write my non-English language:	*N*	Reading mean	Std. dev.
Very well	117	11.98	3.544
Well	124	11.18	4.226
Not well	41	12.20	4.114
Not well at all	33	11.45	4.395
Total	315	11.64	3.991

presented in Tables 32 and 33, these data do not show a relationship between the writing proficiency in the students' primary language and their proficiency in reading English.

Grade 8 Student Background Questionnaire

Tables 35 through 47 present a summary of responses of Grade 8 students to the background questions. As data in these tables show, the trend of responses for Grade 8 students was very similar to those reported for Grade 4 students. In general, students who were born in, or received most of their education outside, the United States performed lower than those in the U.S. Similarly, students who spoke a language other than English performed lower than students who spoke English at home. We will discuss these results for each question briefly.

Table 35 summarizes responses to question 1 (country of birth) in relation to the reading scores. Response categories with a response frequency of less than 10 will not be discussed. The reading score mean for those born in the United States (M = 12.99, SD = 3.79, n = 334) was higher than those born outside the U.S. (for students born in Mexico, M = 11.04, SD = 3.96, n = 98; and for students born in other countries M = 10.32, SD = 4.03, n = 94). This variable is related indirectly to student language background.

Table 36 reports the reading scores by the categories of question 2, time lived in the United States. As the data suggest, the trend was increasing reading score means with the increase of years lived in the U.S. That is, the longer students had lived in the U.S., the higher their reading mean score was. This variable was also related to student language background.

Table 35

Grade 8 Background Question #1 - Country of Birth

1. I was born in:	*N*	Reading mean	Std. dev.
China	5	10.40	5.55
Korea	7	8.43	3.95
Mexico	98	11.04	3.96
The United States	334	12.99	3.79
Other	94	10.32	4.03
Total	538	12.09	4.05

Table 36

Grade 8 Background Question #2 - Time Lived in the U.S.

2. I have lived in the United States:	*N*	Reading mean	Std. dev.
Less than 1 year	32	7.89	3.780
1- 2 years	61	9.13	3.898
3 - 4 years	33	10.89	3.409
5 - 6 years	24	12.13	3.564
7 - 8 years	28	12.46	3.958
Between 9 and 14 years	51	12.17	3.841
All my life	310	13.16	3.672
Total	539	12.07	4.055

Table 37 reports reading score means by the starting grade in the United States. Consistent with results for Grade 4 students, the sooner students entered U.S. schools, the higher the level of their reading. Once again, this is consistent with our earlier discussion of the impact of student language background on their performance.

Self-reported data for Grade 4 suggests that some school resources may have positive effects on student academic performance. Data for Grade 8 confirms this finding. As data in Table 38 show, for example, the availability of an English dictionary, a computer word processor, access to the Internet, and access to a library helped students.

Table 37

Grade 8 Background Question #3 – Grade Starting in the U.S.

3. I started school in the United States in:	*N*	Reading mean	Std. dev.
Preschool	242	13.06	3.795
Kindergarten	126	12.89	3.722
1st grade	10	11.95	4.669
2nd grade	17	12.29	3.869
3rd grade	13	11.12	2.902
4th grade	16	11.19	3.898
5th grade	17	10.79	2.818
6th grade	32	10.45	4.411
7th grade	40	8.75	3.436
8th grade	27	7.72	3.859
Total	542	12.05	4.064

Table 38

Grade 8 Background Question #4 - Resources Used in the School

4. I have used these in my school: (Choose all that apply)	*N*	Reading mean	Std. dev.
English dictionary	442	12.64	3.917
Bilingual dictionary	106	10.49	3.654
Word processor on a computer	211	13.36	4.011
The Internet	288	13.03	4.008
Computer tests	195	12.67	4.068
In school tutor	66	12.70	3.970
After school tutor	139	12.74	3.867
Library	344	13.07	3.943

Table 39 shows data on students' desire to obtain some resources. Students who felt a need for a resource may perform lower than many other groups. For example, for students who express a need for access to a dictionary, having a dictionary may help them improve their performance.

Table 39

Grade 8 Background Question #5 - Resources Needed in School

5. I wish my classroom had: (Choose all that apply)	*N*	Reading mean	Std. dev.
English dictionary	78	10.62	4.181
Bilingual dictionary	111	11.32	4.271
Word processor on a computer	141	11.99	3.832
The Internet	275	12.25	3.846
Computer tests	205	12.53	4.143
In school tutor	62	12.62	4.106
After school tutor	31	10.58	3.704
Library	56	11.06	3.678

Table 40 shows the relationship between understanding the teacher's directions and reading scores. Students who indicated that they understood their teacher's directions had higher reading scores than those who had difficulty understanding the teacher.

Table 41 shows that self-reported performance in math was related to students' reading scores. As the data in Table 41 show, there was an increasing trend in reading scores associated with students' impression of their higher performance in math. Students who indicated that they did not understand what their teacher says in English obtained the lowest scores in reading ($M = 8.75$, $SD = 2.43$, $n = 20$). For students who indicated that they learn as others learn, the mean was 12.90 ($SD = 3.86$, $n = 296$).

Table 40

Grade 8 Background Question #6 - Understanding the Teacher's Directions

6. I can understand my teachers when they give directions in English:	*N*	Reading mean	Std. dev.
Very well	291	12.99	4.074
Well	215	11.17	3.750
Not well	22	9.98	3.479
Not well at all	5	10.50	3.873
Total	533	12.10	4.036

74

Table 41

Grade 8 Background Question #9 - How Well Learning Math This Year

9. How well are you learning math this year?	*N*	Reading mean	Std. dev.
I don't understand what the teacher is saying in English.	20	8.75	2.43
I am learning less math than many eighth graders.	109	11.56	3.79
I am learning as much math as other eighth graders.	296	12.90	3.86
I am learning more math than many eighth graders.	80	11.98	4.35
I am not taking math right now.	8	6.38	1.60
Total	513	12.21	4.02

Table 42 reports students' complaints about math tests and their reading scores. Similar to what was reported for Grade 4 students, students in Grade 8 who expressed difficulty with the test language had lower reading performance than those having difficulty with the content of the questions.

Table 43 reports the language spoken before going school, which is related to reading scores in Grade 4. Similarly, for Grade 8, this variable seems to impact students' reading scores. Students who, before starting school, spoke a language other than English showed lower reading performance than those who spoke English.

Table 42

Grade 8 Background Question #10 - Main Complaint About Math Tests

10. What is your main complaint about math tests?	*N*	Reading mean	Std. dev.
They are hard to read.	64	10.87	3.872
They are hard math problems to answer.	183	11.40	4.009
They ask about math I haven't learned yet.	248	12.85	4.051
Total	495	12.06	4.087

Table 43

Grade 8 Background Question #11 - Language Spoken Prior to Schooling

11. Before I started going to school I spoke: (Choose all that apply)	*N*	Reading mean	Std. dev.
English	298	12.84	4.031
Chinese	9	12.06	4.475
Korean	8	9.13	4.155
Spanish	303	11.62	3.786
Other	47	12.00	4.464

In the CRESST studies on the impact of language on performance, it was demonstrated that language spoken at home was related to students' performance in school. Students who spoke a language other than English at home, in general, had lower performance than those who spoke English (see, for example, Abedi & Lord, 2001). The results of this study on the relationship between home language and performance confirm our earlier findings that students who speak a language other than English had lower reading scores than those who speak English at home (Table 44).

Tables 45 through 47 show the relationship between students' level of efficiency in their primary language and their reading scores. Table 45 shows that the higher the level of students' self-reported proficiency in speaking, the higher was their English reading score. However, this relationship was not quite clear for reading in Table 46, or for writing in Table 47.

Table 44

Grade 8 Background Question #12 – Language Now Spoken at Home

12. Now, at home, we mostly speak:	*N*	Reading mean	Std. dev.
English	224	13.24	3.994
Chinese	6	12.33	4.367
Korean	9	9.78	4.353
Spanish	244	11.28	3.779
Other	36	10.79	4.426
Total	519	12.08	4.057

Table 45

Grade 8 Background Question #13 - I Can Speak My Non-English Language

13. I can now speak that language:	*N*	Reading mean	Std. dev.
Very well	123	11.51	3.418
Well	141	11.27	4.224
Not well	25	9.30	3.674
Not well at all	2	7.00	2.828
Total	291	11.17	3.892

Table 46

Grade 8 Background Question #14 - I Can Read My Non-English Language

14. I can now read that language:	*N*	Reading mean	Std. dev.
Very well	105	11.64	3.502
Well	134	10.91	4.018
Not well	36	9.97	4.364
Not well at all	16	13.38	3.304
Total	291	11.19	3.902

As data in Table 46 show, there was an increasing trend in students' English reading scores with the increasing trend in students' self-reported reading proficiency in their primary language. However, this trend does not continue for all categories of the self-reported proficiency. Students who indicated that they did not read well at all in their primary language had higher reading scores than those who indicated that they read very well in their primary language.

Table 47 shows the relationship between students' ability to write their primary language and their English reading score. While there was a small positive increasing trend, as with the reading data presented above, the trend did not continue.

Predicting Scores From Background Questions: A Multiple Regression Approach

The student background questionnaire was developed to collect data on students' background characteristics that are related to their school achievement. In developing the background questionnaire, the focus was on language background questions. Background questions are an important part of NAEP. The background

Table 47

Grade 8 Background Question #15 - I Can Write My Non-English Language

15. I can now write that language:	*N*	Reading mean	Std. dev.
Very well	87	11.40	3.568
Well	142	10.88	4.049
Not well	42	10.98	4.051
Not well at all	21	12.83	3.610
Total	292	11.19	3.896

questionnaire of this study includes some of the NAEP background questions as well as additional questions on students' language background. To examine the importance of the background questions in students' achievement, we tried to predict math and reading scores from the background questions. However, prior to using background questions as predictors of students' math and reading performance, we examined the characteristics of these variables through descriptive analyses of these variables, as described in the last section.

By examining the results of descriptive analyses, a set of variables from the background questionnaire was selected as predictors in multiple regression analyses. Table 48 shows these variables.

Table 48

Selected Variables From the Background Questionnaires as Predictors of Math and Reading

Q #	Question
1	Born in the United States
2	Time lived in the United States
3	Starting grade in the United States
4	School resources
9	How well learning math
10	Complaints about math tests
11	Home language before going school
12	Language spoken at home currently

We created two multiple regression models. In both models, the above nine background variables were used as predictors. In the first model, the score of English reading was used as the criterion variable, and in the second model, the math score was used as the criterion variable. We used the same models on the data from Grades 4 and 8. We will discuss the results of regression analyses separately for each grade.

Regression Results for Grade 4

Table 49 summarizes the results of multiple regression analysis for Grade 4. As the data in Table 49 show, using all nine variables yields an R^2 of .132. That is, about 13% of the variance in reading scores was explained by the background variables. Among the nine predictors, four are strongly related to performance on the reading test. These variables are:

1. whether student attended first grade in the United States
2. how well student claims to be learning math
3. student's complaints about math tests
4. student's opportunity to learn math

Table 49

Grade 4 Background Questions. Multiple Regression (Reading Total Is Outcome Measure). R^2 = .132

	B	Std err.	Beta	T	Sig.
Constant	9.019	1.954		4.615	.000
Time in U.S.	-.121	.250	-.036	-.486	.627
First grade in U.S.	-.785	.221	-.224	-3.555	.000
How well are you learning math?	.811	.229	.148	3.545	.000
Complaints about math tests	.779	.241	.139	3.234	.001
Born in the U.S.	-5.497 E-02	.610	-.005	-.090	.928
School resources	-1.172 E-02	.137	-.004	-.085	.932
Home language prior	.182	.371	.022	.489	.625
Home language now	.655	.347	.083	1.885	.060
Opportunity to learn math	8.754 E-02	.040	.097	2.206	.028

Once again, having attended first grade in the United States, claiming to be learning math well, and having the opportunity to learn a variety of math content areas are the variables most strongly related to higher performance on the reading test.

Table 50 summarizes the results of multiple regression analysis, predicting the math score from the nine background questions. The model had an R^2 of .099, that is, about 10% of the variance of math score was explained by the background questions. Among the most powerful predictors are:

1. whether student started first grade in U.S. schools
2. how well student claims to be learning math
3. student's opportunity to learn math

Regression Results for Grade 8

Two multiple regression models were created for Grade 8. These models are similar to those used for Grade 4. In the first model, the reading score was used as the criterion variable and the nine background variables as predictors. Table 51 presents the results of the first multiple regression model for Grade 4. As the data in Table 51 show, the R^2 for this model was .139 suggesting that about 14% of the

Table 50

Grade 4 Background Questions. Multiple Regression (Math Total Is Outcome Measure). $R^2 = .099$

	B	Std Err.	Beta	T	Sig.
Constant	14.184	3.257		4.355	.000
Time in U.S.	-.617	.416	-.112	-1.483	.139
1st grade in U.S.	-1.297	.368	-.226	-3.523	.000
How well are you learning math	1.334	.381	.149	3.501	.001
Complaints about math tests	.548	.401	.060	1.364	.173
Born in the U.S.	3.331 E-02	1.016	.002	.033	.974
School resources	.393	.228	.077	1.719	.086
Home language prior	-.560	.619	-.041	-.904	.366
Home language now	.380	.579	.029	.657	.512
Opportunity to learn math	.174	.066	.118	2.629	.009

Table 51

Grade 8 Background Questions. Multiple Regression (Reading Total Is Outcome Measure). $R^2 = .139$

	B	Std Err.	Beta	T	Sig.
Constant	.533	2.755		.194	.847
Time in U.S.	1.103	.370	.243	2.978	.003
First grade in U.S.	4.784 E-02	.270	.012	.177	.859
How well are you learning math?	.924	.293	.164	3.155	.002
Complaints about math tests	.518	.296	.090	1.753	.080
Born in the U.S.	-1.245	.716	-.133	-1.740	.083
School resources	.378	.118	.170	3.197	.002
Home language prior	-.534	.497	-.067	-1.074	.283
Home language now	.908	.426	.122	2.133	.034
Opportunity to learn math	6.604 E-02	.034	.103	1.944	.053

variance of reading test score was predicted from the background variables. Among the variables that were most strongly related to learning were:

1. time student has lived in the United States
2. how well the student claims to be learning math
3. the student's use of school resources
4. the language the student currently speaks at home

Table 52 shows the results of MR for Grade 8 using math as the criterion variable. The R^2 of .129 suggests that about 13% of the variance of the math score is explained by the background variables. Among the most powerful predictors are:

1. how well student claims to be learning math
2. student's complaints about math tests
3. student's opportunity to learn math

Table 52

Grade 8 Background Questions. Multiple Regression (Math Total Is Outcome Measure). $R^2 = .129$

	B	Std Err.	Beta	T	Sig.
Constant	2.673	3.420		.782	.435
Time in U.S.	.554	.460	.099	1.206	.229
First grade in U.S.	-.271	.335	-.053	-.808	.420
How well are you learning math?	.905	.363	.130	2.490	.013
Complaints about math tests	.737	.367	.104	2.008	.045
Born in the U.S.	-.543	.888	-.047	-.611	.542
School resources	.375	.147	.137	2.555	.011
Home language prior	-.444	.617	-.045	-.720	.472
Home language now	.619	.528	.068	1.171	.242
Opportunity to learn math	.154	.042	.194	3.646	.000

Discussion

In response to the legislative call for equal educational opportunity for all children, including English language learners, NAEP has recently adopted the policy of inclusion. In order to include English language learners in NAEP and other large-scale assessments and to provide a fair and valid assessment for them, some forms of assessment accommodations have been provided. The purpose of providing accommodations to ELL students is to help them overcome problems due to limited English language proficiency. The main objective of this study was to identify accommodations that can help ELL students with their language deficiencies without altering the construct of the assessment. To identify effective and valid accommodations, two sets of accommodation strategies were included in this study. The first set was selected from those used in NAEP and found effective in increasing the inclusion rate. The second set of accommodations was language related and was among those that researchers found to be effective in reducing the performance gap between ELL students and non-ELL students.

For this study, we selected two samples, one from Grade 4 and one from Grade 8 classes, in order to be consistent with NAEP assessments. Different accommodation plans were used for each grade. For Grade 4, we used four accommodations (customized English dictionary, extra time, small-group testing, and computer testing with a pop-up glossary). For Grade 8, we used a customized English dictionary and a computer version of the math test. We also tested Grade 4 and 8 students under the standard NAEP testing condition.

For this study, students were only available in their intact classrooms; thus, the design of this study was quasi-experimental. Within the intact classrooms, the different accommodation conditions were assigned randomly to students. However, due to logistical issues, smaller numbers of students were tested under some accommodations, such as small-group testing and computer testing. Therefore, some of the students who would have been selected for small-group testing and computer testing were randomly distributed to other accommodation conditions.

Due to the random assignment of students to different accommodation strategies, we did not expect any initial differences in student performance across the accommodation groups. However, because of the small number of students in some groups, we decided to control for possible initial differences in reading using a measure of English reading proficiency as a covariate. Since our search for a single,

reliable, and valid measure of English reading proficiency did not provide us with such a measure, we decided to use a battery of English reading proficiency measures. We used a composite (a simple or a latent composite) of those measures as a covariate.

We examined different accommodations for their: (1) effectiveness, that is, how effective an accommodation is in increasing ELL students' performance; (2) validity, whether an accommodation affects the construct being measured or alters the performance of non-ELL students; and (3) feasibility, whether effective and valid accommodations are also logistically feasible (i.e., easy to implement). For testing the effectiveness of accommodations, we tested students under the standard NAEP condition as a comparison group. For examining the validity of accommodations, we also included non-ELL students to serve as another control or comparison group.

The accommodated assessment subject matter in this study was mathematics. A total of 25 released math items were selected from the recent NAEP assessments and from the Third International Mathematics and Science Study (TIMSS). Items were selected to represent a wide range of content coverage, language, and psychometric characteristics. Both multiple-choice and open-ended items were included. In addition to the math test, we included different measures of English proficiency, an accommodation follow-up questionnaire to collect data on students' impressions regarding the accommodations, a student background questionnaire to collect background data relevant to content-based assessment, and finally, teacher and school questionnaires to collect relevant information from teachers and school officials.

The reading test battery included a section of the Language Assessment Scales (LAS) with a higher level of discrimination power, a 25-minute block of a NAEP reading comprehension test, and a word-recognition test. A latent composite of these measures was obtained through a latent-modeling approach. A simple composite was also computed. These composites were used in separate analyses to control for possible initial English proficiency differences between accommodation groups. Using these composites as covariates, math scores were adjusted for possible initial differences. Adjusted math scores were compared across the accommodation groups using *a priori* or *planned* comparisons.

The results of our analyses for Grade 4 revealed that extra time and computer testing were effective forms of accommodation for ELL students. For non-ELL

students, the results did not show any significant differences between accommodated and non-accommodated assessments. Therefore, the two accommodation strategies showed effectiveness, without posing any threat to the validity of the assessment.

The results indicate that only computer testing is an effective accommodation for the Grade 8 ELL students in this study. This accommodation has no impact on the assessment of non-ELL students, suggesting that the computer testing for Grade 8 can be implemented without a validity concern.

We did not look for differential effects for the multiple-choice and open-ended items separately because there were not enough items in each of the two categories to do so. However, we grouped the items according to their linguistic complexity to examine the validity and effectiveness of accommodations. This is discussed below.

Students' background variables showed a significant impact on their performance in math. These background variables included language-related and other background variables. As we reported earlier, among the background variables that were powerful predictors of student performance were "Time student lived in the U.S.," "How well student claims to be learning math," and "Student's opportunity to learn math." For example, in Grade 4, students who lived in the U.S. for a year had a mean math score of 8.29 (SD = 5.30) as compared to a mean of 12.30 (SD = 3.73) for those who lived their entire life in the U.S. Once again, the predictive power of a variable that may indirectly be linked to the students' language background suggests that language background is a determining factor of test performance. Among variables that are not language related, opportunity to learn (OTL) seemed to have significant impact on student performance.

This discussion focuses on three major themes, some of which are unique to this study: (1) computer testing as a form of accommodation for ELL students; (2) using a composite of multiple measures of students' level of English proficiency, and (3) accommodation impact on measurement with varying degree of linguistic complexity.

Computer Testing With a Pop-up Glossary as a Form of Accommodation for ELL Students

In this study, computer testing was used as an accommodation strategy for elementary and middle school ELL students. (To test for validity, both ELL and non-ELL students participated in taking the computer version of the tests.) As presented

in the previous section of this report, the results of analyses indicated that computer testing was the most effective among other accommodation strategies used in this study. The results also indicated that computer testing was a valid accommodation since it did not affect the performance of non-ELL students.

We believe computer testing was effective because it incorporates into the session an interactive set of accommodation features. While a primary interest in this study was the provision of easy access to glossary help, this accommodation also represented additional characteristics, such as the presentation of a single item at a time; extra time; and a small and novel setting. Below is an elaboration of these features:

Pop-up glossary. One of the most important characteristics of the computer testing was the extensive use of its glossaries by the students. Under the customized English dictionary accommodation, almost no students marked circles to indicate that they had looked up words in the customized dictionary. In Grade 8 classes, 140 of the 204 students with this accommodation marked the sample word everyone was asked to find and mark. Otherwise, a maximum of 4 students marked any given word, such as "growth," on the pages of definitions. In Grade 4 classes, 146 of the 170 students with customized dictionaries marked the sample word as instructed. Technical words such as "grid," "width," and "length" led the words looked up and were marked by 8, 7, and 5 students respectively.

Students assessed under the computer testing approach, however, used their glossary at a much higher rate than the customized English dictionary group. Students taking the computer version of the math test had access to a "pop-up glossary," a feature that provided a simple gloss of words when students pointed to them with the mouse. The program timed the length of time students spend on each test item. The computer also kept track of which glossary items the students looked up and how long the mouse stayed in that position. The results indicated a large difference between the glossing behavior of ELL and non-ELL students. For example, ELL students in Grade 8 spent nearly three times as much time glossing, and glossed almost twice as many words as non-ELL students.

Delivery of the customized dictionary by computer had several advantages for the students. Students pointed the mouse to an unknown word instead of searching for it in an alphabetical collection. Students were presented with the dictionary entry

of only that word (or its root) in its present context, rather than being given all the possible definition entries.

Presentation of a single item at a time. The ELL students taking the computer version were presented with a single question at a time on the screen in front of them, rather than 15 test pages, each page presenting as many as 3 questions. However, test-wise students noticed the disadvantage of not being able to jump ahead to easier (i.e., multiple-choice) questions, and then return to the harder ones. A few mouse-savvy students used the right button to go back a page to change an answer.

Small, novel setting. Taking a test on a computer—usually in a special room and in a group of about 8—may have been perceived as a privilege rather than a chore. We expected that the randomly selected non-ELL students would also perform better than their "paper-test" peers, but they did not in Grade 4, and the slight increase in Grade 8 did not reach a significant level ($p > 0.05$). The slight difference may be accounted for by familiarity with the keyboard and mouse. As mentioned in the results section, more of the non-ELL students have computers at home (66% non-ELLs; 49% ELLs). Another consideration from test administrator observation is that more non-ELL students possessed the touch-typing skills that made responding to open-ended questions faster.

Computer testing was fun. Students expressed enjoyment of the computer delivery of the test, despite the predominance of "hunt and peck" typing. As discussed in the results section of this report, all students indicated in their background questionnaires that they had more fun with computer testing than with any other accommodation used in this study. A few explained that they preferred backspacing to erasing. Some students used the "copy and paste" mouse technique to answer open-ended questions about the reading passage. A very few figured out how to go back to a previous question without having a "back" button available. (This unfortunately produced multiple answers in the database.) The test administrators noticed that people or noise in the room rarely distracted computer testers.

Feasibility issues with computer testing. Because Internet access was required for administering the computer version of the math and reading tests, testing was limited to certain schools, certain rooms, and computers of a certain size. When we needed to bring laptops to the site, there was at least an hour of setup and another of

clean up. We sometimes had to borrow some of the static IP addresses for that school and type a unique one into each laptop's Internet set-up menu the day before. When using a school's Macintosh computers, some browser versions could not display the pop-up glossary properly, so we had to load new browsers.

If a student accidentally closed the browser when trying to click on the scroll bar, the student's test would be interrupted. This was most common with Grade 4 students trying to use the laptop touchpad instead of the mouse provided. Difficulties beyond student error interrupted testing: a power outage, the UCLA host server being rebooted during a test, and the data server crashing. Because of technical difficulties, some students took the math test on computer, but took the reading test on paper. Thus, while computer testing was a successful accommodation, its implementation was not without logistical problems.

Using a Composite of English Proficiency Measures

Due to the importance of English proficiency measures in the instruction, assessment, and classification of ELL students, we tried to establish a more reliable and valid measure of students' level of English proficiency by compiling a battery of existing measures that are shown to have good measurement properties. We used three measures in this battery: (1) a subscale of the LAS (reading fluency), which has higher discrimination power than other LAS subscales, (2) a 25-minute NAEP reading comprehension block, and (3) a word recognition test. After adjusting for scale differences, we created a simple composite of these components and used this composite as a covariate to adjust for any possible initial differences of students' level of English proficiency. We also created a latent composite based on the fact that the psychometric characteristics of these instruments (e.g., reliability coefficients) are different. Both simple composites and latent composites were used as covariates. In some cases, some differences were observed and the latent composite was a more efficient covariate. However, due to ease of computation and reporting, we used the simple composite in our analyses.

What we learned from using a composite of English proficiency measures was:

1. Multiple measures provide a more stable/reliable measure of English language proficiency—an essential element in studies on ELL assessment; and
2. Care must be taken in the procedure of combining multiple measures of a construct; that is, when multiple measures are used, there needs to be a

more comprehensive approach to the analysis, such as a latent-variable modeling approach.

Among the components used in the English proficiency battery, the word recognition deserves a comment.

Word recognition. An English word recognition measure used on an experimental basis had a significantly high correlation with other reading measures, (so it has some value as an efficient form of reading measurement) but was very likely more difficult to take on a computer than on paper, as the results were so much lower for the computer testing sample. For this reason, it was not used as a covariate in the primary analysis.

Accommodation Impact on Measurement With Degrees of Linguistic Complexity

We categorized math test items based on the level of their linguistic complexity and examined the effectiveness and validity of accommodations on the linguistically more complex and less complex items. We combined items into two categories, less complex (rated 0, 1, or 2, using a linguistic complexity rubric) and more complex (rated 3 or 4). Accordingly, we created two testlets. We then looked at how accommodation effect varied between the two testlets by performing a multivariate analysis of covariance to assess whether the significant accommodation effect found in the total score was due to the complexity of the item.

For the more linguistically complex items, all the accommodations made a significant difference for Grade 4 ELL students. For Grade 8 ELL students, we found that the computer accommodation was significant for the more linguistically complex items (p = .001), but it was not significant for the items that were less linguistically complex. This is additional evidence of the validity of the accommodations by showing that the computer accommodation at Grade 8 only showed an effect on those items for which we would expect language to most disadvantage ELLs.

For the less complex Grade 4 math items, the computer and extra time accommodations were still significant for ELL students. For non-ELL students in Grades 4 and 8, there was no significant accommodation effect; therefore, validity was not a concern for either testlet in either grade.

Recommendations

In this study, we find that the computer accommodation is effective and valid. That is, it can be used on both ELL and non-ELL students without the concern of changing the construct under measurement. Thus, we recommend this accommodation for ELL students when large numbers are included in the assessment. This use, of course, is dependent on an increase in the feasibility of putting together computer tests and administering them at school sites.

A finding that relates OTL to test performance is consistent with the literature and suggests that it is essential that all students have an equal opportunity to learn in schools. We would like to examine the interaction between OTL and students' language background. In this study, however, we did not have enough data to elaborate on such an interaction. We propose that future studies focus on a possible differential level of OTL for students with different language background characteristics.

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APPENDIX A
NUMBERS OF PARTICIPANTS PER ACCOMMODATION PER ELL DESIGNATION PER SITE
DETAILS ABOUT MATH TEST ITEMS

Table A1

Grade 4 Participants

School	Class	N (TOTAL)	N (ELL)	G (TOTAL)	G (ELL)	C (TOTAL)	C (ELL)	S (TOTAL)	S (ELL)	E (TOTAL)	E (ELL)	TOTAL	(ELL)
01	1							7	3	22	3	29	6
	2	12	12	16	16							28	28
02	1									27	18	27	18
	2	14	0	14	1							28	1
	3	5	5	6	6							11	11
	4	7	0	7	0							14	0
03	1	12	5	12	3	7	2					31	10
	2	4	2	4	1							8	3
	3	5	5	5	5							10	10
	4	13	1	10	2	6	2					29	5
	5	12	11	12	11							24	22
04	1	13	8	8	5			4	2			25	15
	2	12	4	11	5							23	9
05	1	8	8	5	5	7	4	4	2			24	19
	2	7	5	5	5							12	10
	3									31	31	31	31
	4	12	0	8	0	6	3					26	3
06	1					5	3			21	16	26	19
	2	13	2	10	2							23	4
	3					5	2			19	4	24	6
07	1					4	2			25	20	29	22
	2					4	2			24	2	28	4
	3					2	1			23	6	25	7
08	1	7	6	9	5	7	2					23	13
	2	8	2	9	3	7	3					24	8
09	1	11	0	8	0	8	2					27	2
	2	10	0	9	0	8	4					27	4
	3	10	3	7	2	8	4					25	9
10	1							5	5			5	5
TOTALS:		195	79	175	77	84	36	20	12	192	100	666	304

Table A2

Grade 8 Participants

School	Class	N (TOTAL)	N (ELL)	G (TOTAL)	G (ELL)	C (TOTAL)	C (ELL)	TOTAL	(ELL)
01	1	13	10	11	9	7	4	31	23
	2	11	11	11	11			22	22
	3	13	4	8	3	7	3	28	10
02	1	16	12	15	14			31	26
	2	16	2	13	3			29	5
03	1	12	1	10	1	7	4	29	6
	2	6	1	4	1	7	4	17	6
04	1	6		9		5		20	0
	2	11	1	10		5		26	1
	3	13	9	12	11	5	5	30	25
05	1	10	1	11	3	10	4	31	8
	2	9	8	7	7	10	10	26	25
	3	8		7		10	1	25	1
	4	16	3	9	1	10	5	35	9
	5	7		6		11		24	0
	6	5	5	4	4	11	11	20	20
06	1					1	1	1	1
	2					16	16	16	16
07	1	13	2	8	4			21	6
	2	11	8	10	8			21	16
	3	15	4	10	6			25	10
	4	13	4	10	6			23	10
	5	10	7	7	4	8	4	25	15
	6	11	2	5	2	8	4	24	8
	7	14	3	6	4	8	4	28	11
	8	12	2	5		8	4	25	6
08	1	1	1			7	1	8	2
	2					2	1	2	1
	3					1	1	1	1
TOTALS:		272	101	208	102	164	87	644	290

Table A3

Grade 4 Math Test Items by Content

Order	ID	Content	Process
9/6	40501	algebra & functions	conceptual understanding
19/14	41101	data analysis, statistics & probability	conceptual knowledge
10/23	40601	data analysis, statistics & probability	conceptual understanding
27/26	69101	data analysis, statistics & probability	problem solving
7/11	68601	data analysis, statistics & probability	knowing procedures
20/16	K-4	data repres., analysis, probability	using complex procedures
5/24	K-1	geometry	conceptual understanding
25/10	K-8	geometry	conceptual understanding
1/3	J-1	geometry	conceptual understanding
26/27	41201	geometry	problem solving
15/18	M-4	geometry	problem solving
18/15	K-7	meas., estimation & number sense	knowing procedures
12/22	L-6	meas., estimation & number sense	problem solving
8/25	J-6	meas., estimation & number sense	problem solving
2/1	40401-3	measurement	conceptual understanding
14/20	69001	measurement	problem solving
17/13	41001	measurement	problem solving
21/17	40901	numbers & operations	conceptual understanding
6/9	68501	numbers & operations	conceptual understanding
11/5	40701	numbers & operations	conceptual understanding
22/4	40301	numbers & operations	conceptual understanding
13/19	68901	numbers & operations	problem solving
4/12	68301	numbers & operations	knowing procedures
24/8	68401	numbers & operations	conceptual understanding
23/7	I-7	patterns, relations, and functions	problem solving
3/2	I-4	whole numbers	knowing procedures
16/21	I-2	fractions and proportionality	conceptual understanding

Table A4

Grade 8 Math Test Items by Content

Order	ID	Content	Process
30/12	R-11	algebra	problem solving
10/32	50801	algebra & functions	problem solving
31/9	50701	algebra & functions	conceptual understanding
20/34	69301	algebra & functions	knowing procedures
33/11	50601	algebra & functions	knowing procedures
27/5	50401	data analysis, stats & prob.	conceptual understanding
35/35	70001	data analysis, stats & prob.	problem solving
1/2	50201-4	data analysis, stats & prob.	problem solving
12/33	K-7	data repres., analysis & prob.	problem solving
2/3	I-6	fractions and number sense	conceptual understanding
23/25	R-13	fractions and number sense	problem solving
16/21	U-1	fractions and number sense	problem solving
18/24	P-9	geometry	knowing procedures
28/8	N-12	geometry	knowing procedures
22/20	51001	geometry	problem solving
21/19	L-15	geometry	problem solving
11/31	P-8	geometry	problem solving
6/29	M-7	geometry	problem solving
14/13	Q-10	geometry	using complex procedures
32/10	R-10	geometry	using complex procedures
34/15	I-3	measurement	conceptual understanding
26/6	N-15	measurement	conceptual understanding
3/4	69401	measurement	conceptual understanding
4/1	M-1	measurement	conceptual understanding
9/30	50501	measurement	knowing procedures
8/27	O-6	measurement	knowing procedures
15/18	69201	numbers & operations	conceptual understanding
13/16	50301	numbers & operations	conceptual understanding
7/28	50001	numbers & operations	conceptual understanding
17/14	50101	numbers & operations	knowing procedures
24/22	69901	numbers & operations	conceptual understanding
29/7	69501	numbers & operations	conceptual understanding
5/26	49901	numbers & operations	conceptual understanding
25/17	69601	numbers & operations	problem solving
19/23	M-6	proportionality	problem solving

Table A5

Linguistic Complexity of Grade 4 Math Items

Order	ID	Word count	Score
1/3	J-1	10	0
2/1	40401-3	10	2
3/2	I-4	5	0
4/12	68301	33	4
5/24	K-1	19	1
6/9	68501	29	3
7/11	68601	31	4
8/25	J-6	5	0
9/6	40501	25	1
10/23	40601	26	3
11/5	40701	37	3
12/22	L-6	25	2
13/19	68901	59	4
14/20	69001	29	2
15/18	M-4	57	4
16/21	I-2	5	0
17/13	41001	22	2
18/15	K-7	24	4
19/14	41101	41	4
20/16	K-4	36	3
21/17	40901	34	3
22/4	40301	6	0
23/7	I-7	34	3
24/8	68401	14	1
25/10	K-8	9	0
26/27	41201	30	3
27/26	69101	47	3

Table A6

Linguistic Complexity of Grade 8 Math Test Items

Order	ID	Word count	Score
1/2	50201-4	81	3
2/3	I-6	8	1
3/4	69401	29	3
4/1	M-1	10	1
5/26	49901	12	3
6/29	M-7	15	2
7/28	50001	10	1
8/27	O-6	31	4
9/30	50501	64	4
10/32	50801	58	3
11/31	P-8	16	1
12/33	K-7	30	3
13/16	50301	17	2
14/13	Q-10	22	2
15/18	69201	36	4
16/21	U-1	57	4
17/14	50101	0	0
18/24	P-9	11	0
19/23	M-6	19	1
20/34	69301	47	4
21/19	L-15	32	3
22/20	51001	60	3
23/25	R-13	15	1
24/22	69901	86	2
25/17	69601	77	4
26/6	N-15	9	1
27/5	50401	59	4
28/8	N-12	29	1
29/7	69501	25	3
30/12	R-11	33	2
31/9	50701	36	4
32/10	R-10	23	2
33/11	50601	12	1
34/15	I-3	11	2
35/35	70001	150	4

APPENDIX B
ACCOMMODATION FOLLOW-UP QUESTIONNAIRE RESULTS

Grade 4 Accommodation Follow-Up Questionnaire Results

A multivariate general linear model was used to examine the relationships among the follow-up questions, accommodation types, and ELL designations. The follow-up questions were the dependent variables, and accommodation type and ELL status were considered fixed factors. Results appear in Table B1.

Significant findings for ELL students. In the math test, ELL students had difficulty understanding more words than did non-ELL students. Few students reported that an English dictionary, a translation dictionary, some words in their language, or all words in their language would help them with the math test. For each of these questions, ELL students felt they would be of help more often than non-ELL students. ELL students were more likely to report that reading the test questions aloud would make the math questions easier.

Significant findings for the accommodation types. Students who took the computer test were much more likely to report that taking the test was "fun" than students with the customized dictionary or standard condition. These students were also more likely to want "more tests like this one." Students who took the computer test or had extra time felt that more pictures would better help them understand the math questions. Students who took the computer test or had extra time were less likely to request a translation dictionary to help them understand the math questions compared to students with the standard condition. Students who took the computer accommodation reported looking up more words during the test.

Table B1

Grade 4 Follow-up Question Means by ELL Status and Accommodation

	ELL		Non-ELL		Total	
Accommodation	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
1. In the math test I did not understand (1-no problem, 2-some words, 3-many words)$_{LI}$						
Computer	1.85	.558	1.53	.505	1.68	.549
Extra time	1.64	.590	1.73	.588	1.68	.589
Cust. dictionary	1.87	.591	1.57	.580	1.69	.601
Standard condition	1.81	.662	1.57	.556	1.68	.615
Total	1.77	.613	1.61	.567	1.68	.594
2a. To make it easier to understand math problems, I would like (1-easier words)						
Computer	.59	.500	.47	.505	.52	.503
Extra time	.51	.503	.50	.503	.50	.501
Cust. dictionary	.54	.502	.42	.496	.47	.501
Standard condition	.44	.500	.48	.502	.46	.500
Total	.51	.501	.47	.500	.48	.500
2b. To make it easier to understand math problems, I would like (1-simpler sentences)						
Computer	.29	.462	.40	.495	.35	.480
Extra time	.26	.444	.29	.454	.27	.448
Cust. dictionary	.25	.434	.31	.464	.28	.452
Standard condition	.34	.477	.32	.467	.33	.471
Total	.29	.453	.32	.466	.30	.460
2c. To make it easier to understand math problems, I would like (1-easier math problems)						
Computer	.38	.493	.37	.489	.38	.488
Extra time	.40	.493	.27	.449	.34	.475
Cust. dictionary	.33	.473	.27	.449	.30	.458
Standard condition	.42	.496	.32	.467	.36	.482
Total	.39	.488	.30	.459	.34	.474
2d. To make it easier to understand math problems, I would like (1-math I learned)						
Computer	.50	.508	.42	.499	.45	.501
Extra time	.62	.488	.49	.503	.56	.498
Cust. dictionary	.48	.504	.51	.503	.49	.502
Standard condition	.51	.503	.46	.501	.48	.501
Total	.54	.500	.47	.500	.50	.500
2e. To make it easier to understand math problems, I would like (1-more pictures)$_{A}$						
Computer	.38	.493	.35	.482	.36	.484
Extra time	.32	.470	.33	.474	.33	.471
Cust. dictionary	.21	.413	.21	.409	.21	.409
Standard condition	.22	.414	.21	.412	.21	.412
Total	.27	.446	.26	.441	.27	.443
2f. To make it easier to understand math problems, I would like (1-an English dictionary)$_{L}$						
Computer	.12	.327	.14	.351	.13	.338
Extra time	.17	.380	.12	.326	.15	.354
Cust. dictionary	.21	.413	.14	.352	.17	.378
Standard condition	.28	.451	.10	.304	.18	.386
Total	.21	.406	.12	.329	.16	.368

Note: L—Significant ELL Main effect $p < .05$;
A—Significant Accommodation Main effect $p < .05$;
I—Significant ELL/accommodation interaction $p < .05$.

Table B2

Grade 8 Follow-up Question Means by ELL Status and Accommodation

	ELL		Non-ELL		Total	
Accommodation	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
2g. To make it easier to understand math problems, I would like (1-translation dictionary)$_{LA}$						
Computer	.15	.359	.05	.213	.09	.289
Extra time	.13	.334	.04	.187	.08	.275
Cust. dictionary	.16	.373	.10	.300	.13	.332
Standard condition	.22	.414	.14	.352	.18	.381
Total	.16	.372	.09	.285	.12	.329
2h. To make it easier to understand math problems, I would like (1-some words in my language)$_{L}$						
Computer	.21	.410	.07	.258	.13	.338
Extra time	.22	.416	.08	.278	.15	.360
Cust. dictionary	.08	.277	.07	.250	.07	.260
Standard condition	.24	.430	.08	.275	.15	.361
Total	.19	.394	.08	.265	.13	.335
2i. To make it easier to understand math problems, I would like (1-all words in my language)$_{L}$						
Computer	.21	.410	.07	.258	.13	.338
Extra time	.13	.334	.08	.278	.11	.308
Cust. dictionary	.20	.401	.07	.250	.12	.324
Standard condition	.15	.361	.10	.304	.12	.331
Total	.16	.368	.08	.275	.12	.323
2j. To make it easier to understand math problems, I would like (1-questions read aloud)$_{L}$						
Computer	.38	.493	.21	.412	.29	.455
Extra time	.25	.437	.18	.385	.22	.413
Cust. dictionary	.20	.401	.24	.431	.22	.418
Standard condition	.24	.430	.12	.329	.18	.381
Total	.25	.435	.18	.388	.21	.411
2k. To make it easier to understand math problems, I would like (more time)$_{A}$						
Computer	.38	.493	.37	.489	.38	.488
Extra time	.37	.485	.30	.460	.33	.473
Cust. dictionary	.46	.502	.54	.501	.51	.502
Standard condition	.47	.502	.48	.502	.47	.501
Total	.42	.495	.43	.496	.43	.495
3. Most of these math problems were (1-very easy, 2-easy, 3-hard, 4-very hard)						
Computer	2.12	.769	2.14	1.246	2.13	1.056
Extra time	2.18	.829	2.05	.805	2.12	.818
Cust. dictionary	2.15	.853	2.18	1.207	2.16	1.076
Standard condition	2.29	1.221	1.89	1.044	2.07	1.141
Total	2.20	.960	2.05	1.069	2.12	1.023

Note: L—Significant ELL Main effect $p < .05$;
A—Significant Accommodation Main effect $p < .05$;
I—Significant ELL/accommodation interaction $p < .05$.

Table B3

Grade 4 Follow-up Question Means by ELL Status and Accommodation

Accommodation	ELL		Non-ELL		Total	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
4a. Taking the test with this accommodation was (1-a little hard) $_{A}$						
Computer	.15	.359	.09	.294	.12	.323
Extra time	.43	.497	.39	.491	.41	.493
Cust. dictionary	.15	.358	.15	.363	.15	.360
Standard condition	.27	.445	.19	.397	.23	.419
Total	.28	.448	.22	.416	.25	.431
4b. Taking the test with this accommodation was (1-hard) $_{L A}$						
Computer	.18	.387	.14	.351	.16	.365
Extra time	.07	.255	.02	.153	.05	.212
Cust. dictionary	.11	.321	.08	.268	.09	.290
Standard condition	.27	.445	.13	.341	.19	.395
Total	.15	.361	.09	.285	.12	.323
4c. Taking the test with this accommodation was (1-same as other math tests)						
Computer	.35	.485	.37	.489	.36	.484
Extra time	.33	.474	.35	.478	.34	.475
Cust. dictionary	.38	.489	.41	.494	.39	.490
Standard condition	.38	.488	.37	.485	.37	.485
Total	.36	.481	.37	.484	.37	.483
4d. Taking the test with this accommodation was (1-easy) $_{A}$						
Computer	.59	.500	.37	.489	.47	.502
Extra time	.24	.430	.39	.491	.32	.466
Cust. dictionary	.39	.493	.48	.502	.45	.499
Standard condition	.42	.496	.50	.503	.46	.500
Total	.38	.485	.45	.498	.42	.493
4e. Taking the test with this accommodation was (1-fun) $_{AI}$						
Computer	.85	.359	.84	.374	.84	.365
Extra time	.55	.500	.40	.494	.48	.501
Cust. dictionary	.64	.484	.43	.498	.51	.501
Standard condition	.51	.503	.58	.496	.55	.499
Total	.60	.491	.53	.500	.56	.497
5. Did want to look up words during the test (1-no, 2-sometimes, 3-often) $_{A}$						
Computer	1.91	.514	1.95	.653	1.94	.592
Extra time	1.45	.605	1.37	.597	1.41	.601
Cust. dictionary	1.66	1.031	1.47	.603	1.55	.804
Standard condition	1.46	.573	1.52	.864	1.49	.747
Total	1.56	.724	1.53	.719	1.54	.721
8. Would you like your tests to be more like this one (1-yes, 2-no) $_{A}$						
Computer	1.09	.288	1.05	.213	1.06	.248
Extra time	1.24	.430	1.24	.428	1.24	.428
Cust. dictionary	1.15	.358	1.26	.443	1.22	.414
Standard condition	1.15	.361	1.27	.444	1.21	.412
Total	1.17	.378	1.23	.420	1.20	.402

Note: L—Significant ELL Main effect $p < .05$;
A—Significant Accommodation Main effect $p < .05$;
I—Significant ELL/accommodation interaction $p < .05$.

Grade 8 Accommodation Follow-up Questionnaire Results

A multivariate general linear model was used to examine the relationships among the follow-up questions, accommodation types, and ELL designations. The follow-up questions were the dependent variables, and accommodation type and ELL status were considered fixed factors. Results appear in Table B2.

Significant findings for ELL students. In the math test, ELL students had difficulty understanding more words than did non-ELL students. ELL students were more likely to report that more pictures on the math test would make the problems easier to understand. This was especially true for ELL students who took the computer test.

Few students reported that an English dictionary, a translation dictionary, some words in their language, or all words in their language would help them with the math test. For each of these questions ELL students felt they would be of help more often than non-ELL students.

FLL students were less likely to report that the test they took was the same as other math tests.

Significant findings for the accommodation types. Students who took the computer test were much more likely to report that taking the test was "fun" than students with the customized dictionary or standard condition. These students were also more likely to want "more tests like this one."

Students who took the computer test were much more likely to report that taking the test was fun than students with the customized dictionary or standard condition.

A higher percentage of students who took the computer- and customized dictionary-accommodated tests reported that the test was easy compared to those who took the test under the standard condition. Similarly, a lower percentage of those accommodated felt that the math test was hard.

Students who took the computer accommodation reported looking up more words during the test.

Table B4

Grade 8 Follow-up Question Means by ELL Status and Accommodation

	ELL		Non-ELL		Total	
Accommodation	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
1. In the math test I did not understand (1-no problem, 2-some words, 3-many words) L						
Computer	1.99	.615	1.69	.608	1.85	.628
Cust. dictionary	2.02	.628	1.71	.651	1.86	.658
Standard condition	1.94	.795	1.75	.563	1.82	.666
Total	1.98	.680	1.72	.601	1.84	.652
2a. To make it easier to understand math problems, I would like (1-easier words)						
Computer	.41	.495	.40	.494	.41	.493
Cust. dictionary	.37	.485	.32	.468	.34	.476
Standard condition	.40	.493	.38	.486	.38	.488
Total	.39	.489	.36	.482	.38	.485
2b. To make it easier to understand math problems, I would like (1-simpler sentences)						
Computer	.29	.456	.36	.483	.32	.468
Cust. dictionary	.38	.488	.32	.468	.35	.478
Standard condition	.26	.439	.42	.496	.36	.481
Total	.31	.463	.38	.485	.34	.476
2c. To make it easier to understand math problems, I would like (1-easier math problems)						
Computer	.40	.492	.57	.499	.47	.501
Cust. dictionary	.41	.496	.40	.493	.41	.493
Standard condition	.41	.495	.35	.480	.37	.485
Total	.41	.492	.42	.494	.41	.493
2d. To make it easier to understand math problems, I would like (1-math I learned)						
Computer	.46	.501	.54	.502	.49	.502
Cust. dictionary	.45	.501	.45	.500	.45	.499
Standard condition	.45	.501	.50	.502	.48	.501
Total	.45	.499	.49	.501	.47	.500
2e. To make it easier to understand math problems, I would like (1-more pictures) LI						
Computer	.39	.490	.13	.344	.27	.447
Cust. dictionary	.23	.425	.15	.362	.19	.395
Standard condition	.29	.459	.20	.402	.24	.426
Total	.30	.461	.17	.376	.23	.423
2f. To make it easier to understand math problems, I would like (1-an English dictionary) L						
Computer	.18	.387	.12	.327	.15	.362
Cust. dictionary	.18	.389	.08	.277	.13	.339
Standard condition	.21	.406	.12	.326	.15	.361
Total	.19	.393	.11	.311	.15	.354

Note: L—Significant ELL Main effect $p < .05$;
A—Significant Accommodation Main effect $p < .05$;
I—Significant ELL/accommodation interaction $p < .05$.

Grade 8 Follow-up Question Means by ELL Status and Accommodation (cont.)

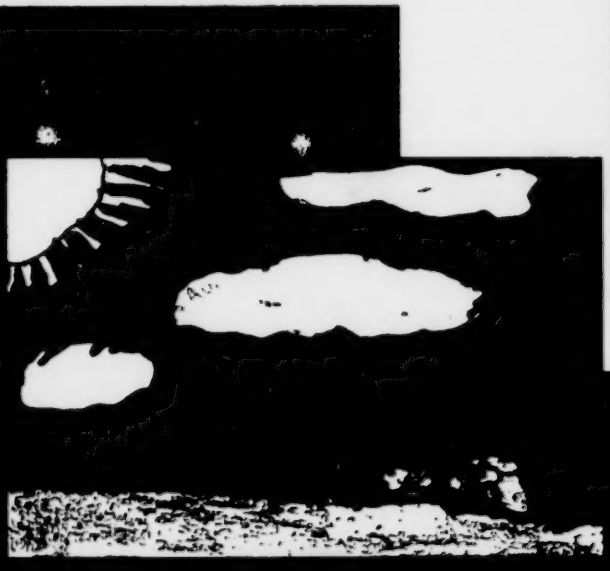
	ELL		Non-ELL		Total	
Accommodation	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
2g. To make it easier to understand math problems, I would like (1-translation dictionary)$_{L}$						
Computer	.11	.313	.06	.239	.09	.282
Cust. dictionary	.11	.315	.06	.237	.08	.278
Standard condition	.15	.363	.04	.197	.08	.278
Total	.12	.330	.05	.219	.08	.279
2h. To make it easier to understand math problems, I would like (1-some words in my language)$_{L}$						
Computer	.11	.313	.07	.265	.09	.292
Cust. dictionary	.18	.389	.11	.310	.14	.352
Standard condition	.18	.386	.03	.177	.09	.285
Total	.16	.364	.06	.247	.11	.310
2i. To make it easier to understand math problems, I would like (1-all words in my language)$_{L}$						
Computer	.13	.341	.06	.239	.10	.301
Cust. dictionary	.13	.343	.09	.294	.11	.318
Standard condition	.13	.336	.03	.177	.07	.254
Total	.13	.339	.06	.234	.09	.290
2j. To make it easier to understand math problems, I would like (1-questions read aloud)						
Computer	.14	.354	.13	.344	.14	.348
Cust. dictionary	.09	.281	.14	.350	.11	.318
Standard condition	.14	.350	.12	.326	.13	.335
Total	.12	.330	.13	.337	.13	.333
2k. To make it easier to understand math problems, I would like (more time)$_{A}$						
Computer	.58	.497	.45	.501	.52	.501
Cust. dictionary	.65	.481	.72	.453	.68	.467
Standard condition	.67	.474	.66	.474	.67	.473
Total	.63	.484	.63	.484	.63	.484
3. Most of these math problems were (1-very easy, 2-easy, 3-hard, 4-very hard)						
Computer	2.58	.843	2.42	.924	2.51	.880
Cust. dictionary	2.52	.959	2.69	1.337	2.61	1.166
Standard condition	2.55	.989	2.50	1.082	2.52	1.045
Total	2.55	.927	2.54	1.134	2.55	1.041
4a. Taking the test with this accommodation was (1-a little hard)$_{A}$						
Computer	.35	.480	.24	.430	.30	.460
Cust. dictionary	.13	.343	.13	.338	.13	.339
Standard condition	.36	.483	.37	.484	.36	.482
Total	.28	.450	.26	.441	.27	.445
4b. Taking the test with this accommodation was (1-hard)$_{A}$						
Computer	.11	.313	.07	.265	.09	.292
Cust. dictionary	.12	.329	.05	.213	.08	.278
Standard condition	.22	.416	.18	.382	.19	.395
Total	.15	.356	.11	.316	.13	.335

Note: L—Significant ELL Main effect $p < .05$;
A—Significant Accommodation Main effect $p < .05$;
I—Significant ELL/accommodation interaction $p < .05$.

Grade 8 Follow-up Question Means by ELL Status and Accommodation (cont.)

	ELL		Non-ELL		Total	
Accommodation	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
4c. Taking the test with this accommodation was (1-same as other math tests)$_{L\,A}$						
Computer	.25	.437	.37	.487	.31	.463
Cust. dictionary	.40	.493	.58	.497	.49	.501
Standard condition	.33	.474	.56	.498	.47	.500
Total	.33	.471	.52	.501	.43	.496
4d. Taking the test with this accommodation was (1-easy)$_{A}$						
Computer	.29	.456	.30	.461	.29	.457
Cust. dictionary	.34	.477	.27	.447	.31	.462
Standard condition	.21	.406	.18	.389	.19	.395
Total	.28	.450	.24	.427	.26	.438
4e. Taking the test with this accommodation was (1-fun)$_{A}$						
Computer	.45	.500	.42	.497	.43	.497
Cust. dictionary	.23	.425	.14	.350	.19	.390
Standard condition	.18	.386	.13	.335	.15	.356
Total	.29	.454	.20	.402	.24	.429
5. Did want to look up words during the test (1-no, 2-sometimes, 3-often)$_{L\,A}$						
Computer	1.93	.620	1.63	.517	1.79	.594
Cust. dictionary	1.62	.601	1.25	.510	1.43	.586
Standard condition	1.69	.631	1.34	.507	1.47	.583
Total	1.75	.629	1.38	.529	1.55	.606
8. Would you like your tests to be more like this one (1-yes, 0-no)$_{L\,A}$						
Computer	.77	.423	.69	.467	.73	.444
Cust. dictionary	.59	.496	.36	.857	.47	.710
Standard condition	.53	.503	.51	.502	.52	.501
Total	.63	.484	.51	.635	.57	.572

Note: L—Significant ELL Main effect $p < .05$;
A—Significant Accommodation Main effect $p < .05$;
I—Significant ELL/accommodation interaction $p < .05$.



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